INDIGENOUS CELLULOSIC RAW MATERIALS FOR THE PRODUCTION OF PULP, PAPER AND BOARD

PART V.—PULPS FOR STRAWBOARDS FROM *ULLA* GRASS (*THEMEDA ARUNDINACEA*) AND *PANNI* GRASS (*VETIVERIA ZIZANIOIDES*)

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SUMMARY

There is a great disparity between the rated capacity and the production of strawboard mills in India due to the shortage of fibrous raw materials. Wheat and rice straws used for the production of these boards are not available to these mills in sufficient quantities as these are required for cattle fodder. Laboratory experiments carried out in this Branch have shown that pulps suitable for strawboards can be prepared from *ulla* grass (*Themeda arundinacea*, Ridley, Syn. *Anthistiria gigantia*, Cav.) and *panni* grass (*Vetiveria zizanioides*, Stapf., Syn. *Andropogon squarrosus*, Hook.) by digestion with lime. Since these grasses have no special use and are burnt down every year to prevent fires in forests, these should be available at cheap rates.

INTRODUCTION

Strawboard is largely used for packing in various forms. It is used as such and also in the form of corrugating boards for boxboard and shipping containers. In India the textile industry consumes a large portion of strawboards. The production of strawboards in this country commenced in 1932 when the first strawboard mill went into production at Saharanpur. Although there are 17 board mills in the country, only 4 are economic units. The production of boards by these mills is very low compared to their rated capacity. In 1949 only 19,585 tons of boards were manufactured although the annual total rated capacity was 45,000 tons. Due to the shortage of fibrous raw materials, the strawboard mills are unable to work to their full capacity and have to remain idle for some months in the year. The domestic annual consumption of strawboards at present is about 50,000 tons and it is expected that this will rise to about 80,000 tons in the next few years with progress in the industry and commerce.

Strawboards are characterized by stiffness, good strength properties, smoothness of surface and adaptability for forming corrugated flutes at high speeds. Wheat and rye straws are very well suited for the production of strawboards. Rice straw, barley straw, bagasse, flax shives and hemp hurds are also used to some extent. In India wheat straw, rice straw, bagasse and some unspecified locally available grasses are used for the manufacture of strawboards. Wheat and rye straws give comparatively a high yield of boards and produce the stiffest boards due to their high hemicellulose contents[1].

The processes used in Europe for the production of straw pulp are described by Atchison[2]. Generally lime is used in Europe and America for the digestion of the straw in spherical rotary digesters. Lime is also used in the Indian board industry for the cooking of the raw materials. The advantages of using lime for the digestion are described by Aronovsky[1]. The low cost and relative insolubility in water are the outstanding advantages of this chemical. Saturated solutions of lime contain small quantities of this chemical. As the lime is used up in the

pulping process, more of the unused material is dissolved, and a saturated solution is thus obtained continually for the pulping of the raw material. Lime thus provides more uniform pulping conditions than other chemicals usually employed for cooking. The disadvantages of lime for the pulping are the difficulties of washing it and its salts from the pulp and the peculiar odour of the manufactured strawboards. The lime salts, when left in the pulps, gradually clog the wire and felts of the board machine, resulting in frequent shutdowns and consequent low production. The life of the machine clothing is shortened by frequent washing of the wire and felts with acid solutions[1]. The odour is objectionable when the board is used for packing food stuffs. Aronovsky and co-workers[3] studied the effect of lime, caustic soda and sodium sulphite as the pulping agents. They found that a mixture of 2% lime and 2% sodium sulphite, based on dry straw, produced an exceptionally free pulp with very good strength properties. When sodium sulphite is used to replace lime in pulping straw for the manufacture of strawboard, the product has considerably less odour than the lime-cooked material[4]. The pulp produced by the sodium sulphite has better strength and operating properties.

As mentioned earlier, the strawboard mills in India are not able to work to their full capacity due to shortage of the fibrous raw materials. Wheat and rice straws are required for cattle fodder. Rice straw is also used for thatching. Bagasse is used in the sugar mills as fuel. Hence the board mills do not get enough supplies of these raw materials. To make up the deficiency they use to some extent certain grasses which are locally available. Even the supplies of these grasses are limited. *Ulla* grass (*Themeda arundinacea*) and *panni* grass (*Vetiveria zizanioides*) are available in large quantities in Northern India where two strawboard mills are situated. *Panni* grass is also available in Madhya Pradesh and Bombay. These grasses have no special use and are burnt down every year to prevent fires in forests. Hence an investigation was carried out in this Branch to test the suitability of these grasses for the production of pulps for strawboards. The results of this investigation are described in this bulletin as an interim report.

CHARACTERISTICS AND DISTRIBUTION

Themeda arundinacea, Ridley, belongs to the family Gramineæ. It is known as *ulla* grass in some parts of Uttar Pradesh. Bor[5] has given a description of this species. It is a tall perennial grass. The culms are 9–18 feet tall, yellow, smooth, polished and elliptic in section. The leaves are long, up to 6 feet and 1 inch in width ; the sheaths are compressed and smooth. The grass flowers in October to December. It is common in low lying well drained soils, and grows in the lower Himalayan region from Kumaon eastwards to Assam. It is usually characteristic of sal (*Shorea robusta*, Gaertn.) forest tracts. It is found in large quantities in Uttar Pradesh, and also in Bihar, Orissa, Assam and Naga and Khasi hills. It occurs in Burma and Malaya. The estimated average annual yield of dry grass is 3·5 tons per acre[6].

Vetiveria zizanioides, Stapf., is a densely tufted perennial grass from a branching root stock with spongy aromatic roots. The culms are stout and up to 5 feet tall and are smooth and glabrous, covered by sheaths which are strongly compressed, especially the lower. The leaves are 1–3 feet long, erect, rigid, firm or somewhat spongy, usually glabrous but sometimes hairy on the upper surface towards the base ; the margins are rough. This species is common on heavy soils in the open where it is often gregarious in thick tufts[7]. It is distributed throughout India ascending to an altitude of 4,000 feet. It also grows in Burma. In India it is found in Punjab, Uttar Pradesh, Bengal, Madhya Pradesh, Bombay and Madras. It flowers in July to January. The estimated average annual yield of the dry grass is 2·4 tons per acre[6]. The fragrant roots of this grass are used for preparing an aromatic and medicinal oil. The well-known *khas khas* mats and hand fans are made from these roots.

THE RAW MATERIALS

The *ulla* grass for this investigation was supplied by the Divisional Forest Officer, Dehra Dun division, from Motichur range. The supplies consisted of culms 4–9′ in length. The *panni* grass was supplied by the Divisional Forest Officer, Karnal division. The culms were 3·5–5′ long. The culms of this grass were separated from another unidentified grass which seemed to grow along with it in the forest.

Preliminary digestions carried out with *ulla* grass showed that crushing of this grass between the rollers of the factory crusher before cutting into pieces of 1″ length yielded well cooked pulp under relatively milder conditions. Hence in all the experiment this grass was crushed and then cut and the pieces obtained in this way were used for the digestion. In the case of *panni* grass crushing was found unnecessary and hence this grass was cut without crushing and then used for the digestion.

PROXIMATE ANALYSIS

These grasses were analysed by the Forest Products Laboratory methods[8] except for the estimation of pentosans where TAPPI standard T 223m–48 was employed. For comparison wheat straw received from the Meerut Strawboard Mills was also analysed. The results of the proximate analysis are given in Table I.

TABLE I

Proximate analysis of ulla grass, panni grass and wheat straw

	% on the oven-dry basis except moisture		
	Ulla grass	*Panni* grass	Wheat straw
1. Moisture	12·59	7·05	10·68
2. Ash	7·41	5·75	3·92
3. Cold water solubility	6·53	5·30	9·57
4. Hot water solubility	10·77	10·18	13·75
5. 1% NaOH solubility	36·25	36·81	34·92
6. 10% KOH solubility	48·02	58·78	40·05
7. Ether solubility	0·24	4·63	0·61
8. Alcohol-benzene solubility ..	3·57	7·86	7·83
9. Pentosans	22·03	25·45	26·22
10. Lignin	31·48	25·80	21·93
11. Cellulose (Cross and Bevan) ..	54·52	45·83	49·05

From the high values for the alkali solubilities and pentosan content it can be concluded that the hemicellulose content of these grasses is high. This is favourable for the property of stiffness in strawboards. The pentosan content of *panni* grass is nearly the same as that of wheat straw and slightly more than that of *ulla* grass. The alkali solubilities of these grasses are more than that of wheat straw.

PRODUCTION OF PULPS

A number of digestions were carried out using lime as the pulping agent. The quantity of lime (CaO) was varied from 10 to 15% on the weight of the air-dry grass, the temperature from 140° to 162°C and the period of cooking from 3 to 6 hours. A material liquor ratio of 1 : 5 was used in all the digestions. As a rotary digester was not available, a vertical stationary digester was used. After the digestion was over, the pulp was washed with water on 60-mesh sieve and worked for 5 minutes in the factory kollergang. The pulp was again washed and worked for 15 minutes in the laboratory kollergang (Jemes d'A Clark's Original Kollergang for Precision Pulp Testing, U.S.A.). The stock was next disintegrated for ½ hour in the laboratory disintegrator and used, after the determination of its freeness, for making board sheets on the standard sheet making machine. These board sheets were conditioned at 65% R.H. and 58°F and tested for tensile strength and bursting strength. The basis weight and thickness of these board sheets were also determined. The digestion conditions, pulp yields and strength properties of the board sheets from *ulla* grass are given in Table II and from *panni* grass in Table III.

DISCUSSION

From the results recorded in Table II it is clear that the digestion of *ulla* grass with 15% lime (on the basis of air-dry grass) at 140°C for 6 hours gives pulp with the best strength properties under the conditions studied. If a lower percentage of lime is used for the digestion, a higher temperature is required to get well cooked pulp with good strength properties. On comparing the results of Serial Nos. 2 and 9 it is seen that at higher temperatures lower percentage of lime for the digestion gives pulps with better strength properties. This is also seen from the results of Serial Nos. 3 and 8.

As reported earlier, it was found necessary to crush the *ulla* grass to get well cooked pulp with relatively mild conditions. Crushing of the grass was found unnecessary in the case of *panni* grass. From the results given in Table III it is seen that the digestion conditions given in Serial Nos. 2 and 9 give pulps with the highest strength properties under the conditions studied. Unlike *ulla* grass, pulps with higher strength properties are not obtained from *panni* grass when the digestion is carried out with a higher percentage of lime (15%) at a lower temperature (140°C). *Panni* grass requires higher temperatures (153–162°C) for pulping even with higher percentage of lime (15%) for obtaining pulps with higher strength properties. *Panni* grass gives a higher yield of pulp than *ulla* grass under the same conditions of digestion.

The results of the proximate analysis of *ulla* and *panni* grass given in Table I indicate that the latter grass contains a higher percentage of hemicellulose. It is well known that hemicellulose is helpful in lowering the time of beating. The values for freeness given in Tables II and III (column 6) show that *panni* grass pulp can be beaten to a higher degree than *ulla* grass pulp in a given period. In other words, *panni* grass pulp requires less time for beating than *ulla* grass pulp to the same degree of freeness.

The colour of the pulps from these two grasses is nearly similar to that of strawboards manufactured in this country.

CONCLUSIONS

1. Well cooked pulps with colour and strength properties suitable for strawboards can be obtained from *panni* grass without prior crushing. *Ulla* grass requires crushing before digestion for getting similar pulps.

2. Under the same conditions of digestion *panni* grass gives a higher yield of pulp than *ulla* grass.

3. Pulps with good strength properties are obtained from *ulla* grass using for the digestion a higher percentage of lime (15%) at a lower temperature (140°C) or a lower percentage of lime (10%) at a higher temperature (162°C), but in the case of *panni* grass a higher temperature (153–162°C) is required even with a higher percentage of lime (15%). Like *ulla* grass, *panni* grass yields good pulp with 10% lime at 162°C.

4. *Panni* grass pulp can be beaten to the required degree of freeness in a shorter time than *ulla* grass pulp.

These conclusions must be confirmed by carrying out large scale trials of pulping and board-making.

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TABLE II

Digestion of Ulla grass and strength properties of board sheets

Material : liquor = 1 : 5. Sheets were conditioned at 65% R.H. and 58°F

DIGESTION CONDITIONS AND PULP YIELDS					STRENGTH PROPERTIES OF BOARD SHEETS							
1	2	3	4	5	6	7	8	9	10	11	12	13
Serial No.	Lime as CaO*	Digestion temperature	Digestion period	Pulp yield*	Freeness	Thickness	Basis weight	Tensile strength	Breaking length	Bursting strength	Burst factor	REMARKS
	%	C	hours	%	c.c. (C.S.F.)	mils (1/1000 in.)	g./sq. metre	Kg. per 15 mm. width	metres	lb./sq. in.		
1	10	153°	6	42·8	536	34·3	503·2	32·1	4250	158·5	22·2	Well cooked pulp
2	10	162°	5	41·5	511	32·5	470·0	34·0	4820	161·0	24·1	,, ,, ,,
3	12	153°	5	44·6	545	29·7	423·1	26·3	4150	153·3	25·5	,, ,, ,,
4	15	140°	3	42·7	407	42·0	627·8	24·7	2620	174·0	19·5	Hard cook
5	15	140°	4	45·3	545	53·0	733·0	28·7	2610	158·6	15·2	,, ,,
6	15	140°	6	44·8	505	28·0	446·2	36·9	5510	182·5	28·8	Well cooked pulp
7	15	153°	4	45·6	396	32·0	521·6	34·7	4440	177·3	23·9	,, ,, ,,
8	15	153°	5	43·7	555	33·8	494·2	25·7	3470	157·5	22·4	,, ,, ,,
9	15	162°	3	44·5	535	33·0	507·2	28·0	3680	170·0	23·6	,, ,, ,,

* The % is expressed on the basis of the air-dry raw material.

TABLE III

Digestion of Panni grass and strength properties of board sheets

Material : liquor = 1 : 5. Sheets were conditioned at 65% R.H. and 58°F

DIGESTION CONDITIONS AND PULP YIELDS					STRENGTH PROPERTIES OF BOARD SHEETS							
1	2	3	4	5	6	7	8	9	10	11	12	13
Serial No.	Lime as CaO*	Digestion temperature	Digestion period	Pulp yield*	Freeness	Thickness	Basis weight	Tensile strength	Breaking length	Bursting strength	Burst factor	REMARKS
	%	C	hours	%	c.c. (C.S.F.)	mils (1/1000 in.)	g./sq. metre	Kg. per 15 mm. width	metres	lb./sq. in.		
1	10	153°	6	48·7	333	25·6	406·4	25·5	4180	114·0	19·7	Well cooked pulp
2	10	162°	5	54·1	314	24·7	412·2	27·3	4420	115·7	19·7	,, ,, ,,
3	12	153°	5	53·4	353	33·3	517·0	27·4	3530	127·3	17·3	,, ,, ,,
4	15	140°	3	54·5	297	33·1	549·5	25·0	3030	142·0	18·2	,, ,, ,,
5	15	140°	4	47·3	292	32·6	557·6	27·6	3300	143·5	18·1	,, ,, ,,
6	15	140°	6	53·8	252	32·9	564·8	28·6	3380	147·3	18·3	,, ,, ,,
7	15	153°	4	55·7	232	29·5	518·0	31·1	4000	143·5	19·5	,, ,, ,,
8	15	153°	5	54·3	232	31·6	547·2	28·4	3460	145·3	18·7	,, ,, ,,
9	15	162°	3	50·5	232	30·9	539·1	34·9	4320	153·7	20·0	,, ,, ,,

* The % is expressed on the basis of the air-dry raw material.

ESPACEMENT IN CINCHONA PLANTATIONS

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SUMMARY

While the technique adopted in raising Cinchona in the South leaves little to be desired, the deleterious effects of congestion on the growth of trees would hit the eye of the most casual visitor. Well-developed trees which happen to possess the growing space, they have, by accident and not by design, provide an indication of the espacement to be aimed at. Pending scientific experimentation, the existing spacing of 4 ft. by 4 ft. should be stepped up to 8 ft. by 8 ft. This will not only ensure better development, but would also reduce the planting costs to at least about a third.

The introduction of Cinchona* in the Nilgiris dates back to 1861, when W. G. McIver, the then Superintendent of the Botanical Gardens, Ootacamund, laid out the first series of experiments at Doddabetta. By 1867, there were 507 acres under Cinchona: 152 acres at Doddabetta, 284 acres at Naduvattam, and 71 acres at Wood Estates. The idea soon caught on and a number of private plantations came into being in Coorg, Sheverois, Palnis, S. Kanara and Tinnevelly. At present the Government Cinchona plantations in the South cover an area of about 10,500 acres, of which the Nilgiris account for about 2,500 acres and the remaining 8,000 acres occur in the Anamalais. They are a fairly large number of privately owned plantations, the largest being those in Tinnevelly owned by the Bombay Burma Trading Corporation. The area of these plantations is not known.

2. Perfected during the best part of a century, the planting technique of this species leaves little to be desired. The elaborate nursery practice, the basket plants, the choice of species, the development of high quinine yielding strains, and the vegetative propagation from patch budding, cuttings and layerings have reached a stage which compels admiration.

3. A visit to the Cinchona plantations at Nongpoh and Umsaw (Shillong plateau) and those at Doddabetta and Naduvattam has left the residual impression upon my mind that all is not well with the prescribed espacement between the Cinchona plants. Every single plantation I inspected showed signs of congestion, struggle for existence, and curvature due to helitropism. In plantations so elaborately raised, where each transplant put out represents a fair amount of money, thinnings are out of the question. As Cinchona is raised for bark, the form of the stem is of little consequence—a major consideration in the raising of timber trees.

4. The standard practice adopted in the South as also in Assam is to put out transplants 4 ft. by 4 ft. Depending upon the vigour of growth, congestion usually begins to exhibit itself from about the 5th year onwards. The rotation usually adopted is 8 to 10 years. Instead of putting on a girth (whence bark) increment during the years immediately preceding their exploitation, trees seem to spend most of their energy in struggling for overhead light and consequently develop lanky, bent and indifferent boles. So far as the overhead light is concerned the optimum space required for a tree for full and unrestricted development throughout its life is indicated by the diameter of its crown at the age, it is to be felled. Freedom from competition for light is secured if crowns of trees just touch but do not overlap

* After the Countess of Chinchona, the wife of the Spanish Viceroy of Peru, who was cured of her fever by the bark of this plant which occurs naturally in Peru and Bolivia. Introduced by the Spanish Jesuits to the Western World, the bark was used as such until 1820, when the French Chemists recovered from it the alkaloid known as quinine.

at any stage in their life. Viewed against this background, recent measurements of the crown-spread of well-grown trees of the rotation age (10 years) at Naduvattam are instructive :—

Height Feet	Girth Inches	Crown spread Feet	
18	13·5	10	
16	14	12·2	
16	16	13·2	
16·6	14·5	11·8	Average.

These trees happened to possess the growing space, they have, not by design, but by accident. They were either on the border line or their adjoining trees had died. The crown-spread of the trees grown at the standard espacement of 4 ft. by 4 ft. was as under :—

Height Feet	Girth Inches	Crown spread Feet	
8	5·6	4	
10	6	4·2	
9	6	4·5	
9	5·9	4·2	Average.

The comparative development of these trees calls for no comments.

5. It is instructive to note that seed-bearers which are selected for their good development, height and crown-spread, and high quinine contents are usually the trees which by accident have come to enjoy more growing space than others.

6. While detailed investigations by laying out comparable plots with 4, 6, 8 and 10 ft. spacing may be undertaken, we might take the cue in the meanwhile from well-grown trees which have accidentally come to occupy the optimum spacing in a plantation at the rotation age. Any one who runs can see that the existing espacement of 4 ft. by 4 ft. is not enough for the proper development of plants. While most well-grown trees on fertile well-drained loams demand a spacing of about 10 to 12 feet, it will be safe to adopt an 8 by 8 ft. spacing. The number of plants required will be reduced to a fourth (from about 2,720 to 680) and plantation costs to at least about a third. The yield of bark from 680 well-grown trees will be vastly greater than that from 2,720 trees indifferently developed.

7. Mention may be made here of the 3 ft. by 3 ft. spacing adopted during the World War by Russia. The object, I understand, was to use the plant-lock, stock and barrel.

8. While on the subject mention may also be made of the shelter trees in Cinchona plantations. Leguminous light-crowned species such as wattle and Albizzias are strongly recommended both for the shade they provide and for their soil enriching properties.

THE APPLICATION OF SELECTIVE HERBICIDES TO FORESTRY PRACTICE

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(*Continued from* The Indian Forester, *March 1951, page 191*)

SUMMARY

1. In Part I, some of the general aspects of selective methods of weed control have been discussed in relation to the historical development of the technique, properties, mode of action and methods of application of herbicides in practice.

2. Part II deals with the application and scope of this technique in forestry practice, such as the eradication of undesirable species in the forest and the control of weeds in forest nurseries.

3. Investigations into the herbicidal effects of 3 phenoxy-acetic compounds (Na. M.C.P.A., Na. D.C.P.A., T.C.P.A.) and I.P.C. on the pre-emergent stages of 11 tree species (both coniferous and broad-leaved) have revealed varying degrees of toxicity. I.P.C. in general has proved to be less toxic than the phenoxy-acetic compounds ; the latter being comparatively more toxic to the broad-leaved species than to the conifers. A comparison of probit lines derived from the mortality figures has indicated a lesser variability in the response of *Acacia catechu* and Norway pine to concentrations of the phenoxy-acetic compounds than in the case of other species.

4. From investigations into the effects of a variety of herbicides-inorganic, organic, growth substances and petroleum fractions on the post-emergent stages of Scots pine, Sitka spruce and Japanese larch grown in pots and nursery beds, it appears that the lighter oil fractions show the greatest promise for weed control in forest nurseries. Potassium ethyl xanthate with Sitka spruce and Scots pine, Amm. D.N.B.P. with Scots pine and the growth substances are worthy of further trials. The remaining compounds, amm. sulphamate, sodium thiocyanate, sodium pentachloro-phenate, diesel oil and lubricating oil extract have proved too toxic.

DISCUSSION OF RESULTS AND CONCLUSIONS

Laboratory germination tests.—The successful outcome of these experiments, in particular the convertability of the majority of the results into probit lines, indicates that the technique adopted can be regarded as satisfactory. Although no definite standard for distinguishing a germinated from an ungerminated seedling could be fixed, the arbitrary standard employed (viz., seedling length) has given satisfactory results. Moreover, the use of sand as a medium for germination has facilitated the application of herbicides not sufficiently soluble in water.

As might be expected, a comparison of L.D. 50s (cf. Table I, p. 28) indicates that the different herbicides show various degrees of toxicity to the different species. I.P.C. proved invariably less toxic than the phenoxy-acetic acids for all species. Amongst the phenoxy-acetic acids D.C.P.A. appears to be generally the most toxic whilst T.C.P.A. shows a very variable behaviour.

Although a comparison of L.D. 50s gives some idea as to the comparative toxicity of various chemicals to various species, more useful information for selective weed control purposes can be derived from a study of L.D. 20s or L.D. 0s—the general idea of such studies being to discover chemicals which at a certain concentration will kill weeds but will not harm

the tree seedlings, at least appreciably. The results were, therefore, transformed into probit lines so that direct comparisons could be made. Besides facilitating the comparison of toxicities at various levels (L.D. 0 to L.D. 100), this comparison revealed some interesting information regarding the behaviour of germinating seeds of the different species.

In the case of the phenoxy-acetic acids (cf. Appendix II, Graphs 10, 11 and 12) the probit lines for *Acacia catechu* and *Pinus resinosa* showed a much steeper slope than those for the other species. This means that the seeds of these species are more resistant to lower concentrations of the chemicals but that, with the increasing concentrations, their susceptibility increases at a higher rate than that of the other species. In other words, the seeds of *Acacia catechu* and *Pinus resinosa* are less variable in their reaction to these chemicals than are the other species. The fact that of the coniferous species, *Pinus resinosa* appears to be the most susceptible species at higher concentrations and the least susceptible at lower concentrations has obviously an important bearing on the study of selective methods of weed control.

It may, however, be emphasized that the results obtained from such laboratory tests cannot be applied directly to field experiments. Various factors such as soil type, weather, etc., affect the toxicity of chemicals under field conditions and thus a measure of toxicity arrived at in a laboratory experiment of this kind cannot always be expected to correspond to that in the field. Allard, De Rose and Swanson (1946) who studied the effects of growth substances on the germination of cereals and broad-leaved weed species have also stressed this point in their report. Nevertheless, such findings may be of great help in forecasting the differential toxicity of a particular compound to various species growing in the field. Such a differential toxicity for example has been demonstrated by Sanzen Baker and Templeman (1947) when treatment of Scots pine and European larch seed-beds with Na. M.C.P.A. resulted in considerable damage to the European larch but did little harm to the Scots pine.

Reports from various investigators to the effect that growth substances in minute doses stimulate the growth of seedlings have also been substantiated by these experiments.

Field experiments.—It may be emphasized that these experiments were carried out merely with the object of obtaining preliminary indications as to the applicability of the various herbicides in nursery practice. The technique differs from that adopted for the laboratory experiments in that post-emergent treatments were investigated rather than pre-emergent treatments. In view of the preliminary nature of these field trials the results obtained have not been subjected to detailed statistical analysis. However, from a study of Tables 2 and 3 some useful information can be obtained, but it must be pointed out that these inferences cannot be regarded as definite recommendations unless they are confirmed by further detailed investigations.

Assuming that concentrations of the growth substances, Na. M.C.P.A., Na. D.C.P.A., and Na. T.C.P.A., of about 0·2% are generally satisfactory for weed control (cf. Appendix I and III), the percentage kills obtained with these chemicals after 1 month or more suggest that none of these substances except possibly Na. T.C.P.A. with Scots pine and Sitka spruce is really suitable in nursery practice for any of the three species tested. The figures for percentage kills after 15 days are of course much lower but the growth substances are slow acting and hence the data obtained soon after treatment do not give a true picture of the reaction at a later stage. Nevertheless, in view of the slightly different results obtained in the experiments carried out, for the last two years, by the Agriculture Research Council and the Forestry Commission of England (cf. Appendix IV) further investigations are necessary before any definite recommendations can be made.

Neither of the inorganic compounds, Ammonium sulphamate nor Sodium thiocyanate, appear to show any great promise as selective herbicides in nursery practice. The concentration of these substances generally suggested for weed control in about 2–4% and, as the

results indicate, such concentrations are too toxic towards the tree species tested. Sodium thiocyanate appears to be very quick acting but Ammonium sulphamate is much less so: 15 days after spraying Ammonium sulphamate gives very little kill but like the growth substances its real toxic effects appear at a later date, probably when the toxicant is transported down to the roots.

Of the organic compounds tried, viz., potassium ethyl xanthate, Ammonium D.N.B.P. and Sodium pentachlorophenate, the last has proved to be very toxic to all three tree species, even at concentrations lower than those recommended for weed control (cf. Appendix I). There is, however, a suggestion that potassium ethyl xanthate deserves further trials with Sitka spruce and Scots pine, since at a concentration of 1% which is judged satisfactory for weed control, the mortality of Sitka spruce and Scots pine cannot be considered too high. Ammonium D.N.B.P. has proved very toxic to Japanese larch and Sitka spruce but may be worth further investigations with Scots pine.

With the exception of diesel oil and the lubricating oil extract all other oil fractions tested have shown distinct possibilities for their use in coniferous nurseries. However, the high susceptibility of Japanese larch to Esso vaporizing oil suggests that deciduous coniferous species may behave differently compared with other evergreen species and this deserves careful investigation before any definite conclusions can be drawn.

Of all the oil fractions tested the Anglo-Iranian white spirit appears to be the least toxic to all three coniferous species, viz., Japanese larch, Scots pine and Sitka spruce. It is, however, of interest to note that white spirits in general have been reported to be less toxic to weeds than are the vaporizing oils.

It has been observed that, although oils appear to kill many weeds, they do not always stop them from sprouting and, therefore, from several applications during the season may be necessary to obtain efficient control of weeds in nursery beds. Nevertheless, even if they do not kill all the weeds, oils certainly reduce their intensity of growth. A considerable saving in time and cost can thus be affected by the use of oil sprays along with hand weeding. Eliason (1949) has reported a saving of about 50% in weeding costs by this combined treatment.

The results of the field experiments may be conveniently summarized as follows :—

TABLE 4

Herbicide	Species		
	Scots pine	Sitka spruce	Japanese larch
Amm. sulphamate	X	X	X
Sodium thiocyanate	X	X	X
Pot. ethyl xanthate	II	II	X
Amm. D.N.B.P.	II	X	X
Sod. penta-chloro-phenate ..	X	X	X
Na. M.C.P.A.	II	II	II
Na. D.C.P.A.	II	II	II
Na. T.C.P.A.	II	II	II
Esso vaporizing oil	I	I	X
Regent ,, ,, ...	I	I	I

(*contd.*)

TABLE 4—(*concld.*)

Herbicide	Species		
	Scots pine	Sitka spruce	Japanese larch
Shell T.P. 711	I	I	I
A.I. White spirit W8/72 ..	I	I	I
Varsol	I	I	I
Diesel oil	X	X	X
Extract W8/395	II	II	II
Extract W8/409	II	II	II
Shell H.10	II	I	I
Extract W8/404	X	X	X

X — indicates no possible application in nursery practice.
I = indicates possibilities in nursery practice.
II = indicates need for further trials.

THE FUTURE OF HERBICIDES IN FORESTRY

The fact that selective herbicides can play a very important role in forest economics cannot be disputed. One of the great problems in Forestry operations today is that of increasing cost and shortage of labour, so much so that many schemes in several countries have had to be postponed owing to lack of funds and man power. Clearing of fire-lines, rights of ways, paths and roads and the control of noxious plant growth in plantation and regeneration areas are some of the major works essential for the more efficient management of forests. These involve considerable expenditure and hard work which, if saved, could be utilized more profitably elsewhere. Recent reports from America on the clearing of fire-lines by chemical sprays (Blanchard 1947), the eradication of poison-oak (*Rhus diversiloba*) from human habitations (Hartman and Offerd 1947), the control of *Ribes* spp., as a means of eradicating white pine blister rust, the control of aspen for the restoration of conifers and the control of woody and herbaceous weeds in plantations and regeneration areas, illustrate the tremendous practical applications of this technique.

The eradication of weed growth for example, has obvious advantages in various silvicultural operations such as the establishment of natural regeneration and plantations. In such cases adequate control of noxious growth, whether herbs, shrubs or grasses is one of the most important factors. In many parts of the world, successful regeneration of forests has become extremely difficult because of the invasion of undesirable plant communities. In England for example excessive growth of brambles, *Molinia* and bracken, has been known to cause considerable difficulty in the establishment of coniferous seedlings. In many parts of the dry deciduous forests in India invasion by tall, thick and coarse grasses is an unsurmountable difficulty. The Americans are faced with similar problems associated with low value hardwood species. Mechanical eradication is expensive and does not prevent sprouting of stumps; burning may be partly effective in damper areas but is dangerous in the drier parts, nor does it necessarily stop sprouting. Burning may even kill wanted trees along with

unwanted or destroy seeds on the ground, and sometimes accelerate erosion. Selective herbicides appear to have overcome all these disadvantages. They have been known to stop sprouting and kill only the undesirable species, moreover they can achieve this result at a much lower cost.

Another example of silvicultural operations in which selective herbicides can be of great value is that of climber cutting. In tropical forests, climbers are often a great nuisance in young plantations and regeneration areas. They have to be cut frequently if they are not to kill and destroy the young growth, since they sprout fairly quickly and uprooting is a very expensive procedure. If herbicides could be found which would kill the climbers and not the trees they would be most valuable.

Selective herbicides may play an even more important role in the weeding of forest nurseries. More than half the cost of growing forest tree planting stock has been reported to be due to the eradication of weeds in seed beds and transplant areas (Eliason 1949). Weeding costs in nurseries in England at the present time may rise to as high as £250 to £300 per acre, which is a serious handicap to large scale afforestation programmes. The control of weeds in coniferous nurseries by such compounds as mineral oils and 2, 4-D sprays gives promise of a successful solution to this problem. In fact, results have shown that the use of oil sprays has reduced weeding costs by as much as 50 to 80% and has at the same time increased the annual production of planting stock. By using oil sprays the Southern States of America anticipate a saving of $100,000 in the weeding costs of nurseries during 1949 (Anon 1948).

An additional advantage resulting from the use of selective herbicides in weed control is the avoidance of the loss of stock seedlings which invariably occurs with hand weeding and which in some cases may be as high as 10–15%.

The problem of grazing and pasture lands is always intimately linked up with the forests of a country. For efficient control, management and maintenance of adequate forests it is essential that grazing grounds, inside or outside the forests, should be maintained in a fit condition for the live stock. Here again, selective herbicides can be of great help in controlling undesirable hardwood species, which so often invade pasture lands and reduce their forage value (Campbell and Peevy 1945).

Though there is considerable scope for the use of selective herbicides in forestry practice and some promising results have already been achieved, the application of this technique on a large scale needs considerable research on the properties of the compounds and their effects on various plant species, before any definite programme can be drawn up. The costs of some of the new herbicides is at present prohibitive for use in large scale forestry operations, but it is quite possible that as the demand for these substances increases, so the cost will fall to more reasonable levels.

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APPENDIX I

Properties of the Herbicides used in the tests

INORGANIC COMPOUNDS

1. *Ammonium sulphamate* ($NH_4 SO_3 NH_2$)

Developed in the United States of America mainly for killing trees and also shrubs like poison ivy (*Rhus toxicodendron*). Little is known about its potentialities as a selective herbicide or its effect on herbaceous weeds. It has been tried in England on ragwort (*Senecio jacobœa*), a perennial weed in pasture lands, but it was not successful. It is soluble in water.

2. *Sodium thiocyanate* (Na C N S)

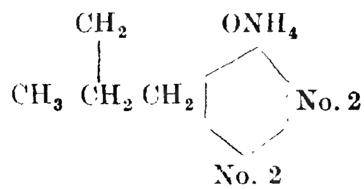
This has been tried as a soil sterilant for a long time but with little success. Interest in its use as a selective herbicide has been shown only recently, e.g., it has been used as a selective herbicide for onions. It is effective against annual weeds in the seedling stage at about 4% concentration and is very expensive at the moment. It is soluble in water.

ORGANIC COMPOUNDS

1. *Potassium ethyl xanthate*, ($KO C_2 H_5 CS_2$)

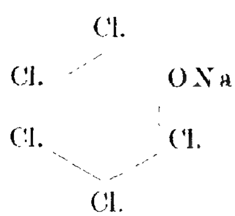
Xanthates have been tried out as soil sterilants since about 1936 but little is so far known about their selective herbicidal properties. It is very soluble in water.

2. *Ammonium dinitro-secondary-butyl-phenol*



This is a homologue of dinitro-ortho-cresol whose selective herbicidal properties have been known for a very long time. It is more toxic to weeds than D.N.O.C. and has also some selective properties not possessed by D.N.O.C. such as with lucerne and peas. It was first developed as a selective herbicide in the United States in about 1945. Within the last 3 years considerable experimental work has been done in England and it is now available on a commercial scale. Generally 0·2% solutions have been found effective for the control of a wide range of weeds in England but it appears to be effective only against annual weeds. It is only slightly soluble in water.

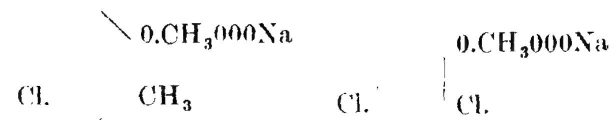
3. *Sodium-penta-chloro-phenate*



This was developed as a selective herbicide in France, during the war, as a substitute for D.N.O.C. and is still subject to considerable experimental interest for a variety of herbicidal uses. It is also used as a fortifying agent for contact herbicides and has been tried for pre-emergent treatments on various crops as well as a selective post-emergent spray. It kills much the same sort of weeds as D.N.O.C. but at higher concentrations and is only effective against annual weeds. For efficient weed control 1% to 2% solutions have been found satisfactory. It is soluble in water.

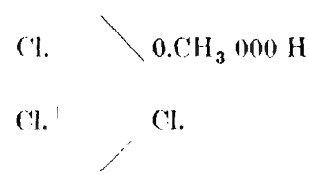
GROWTH SUBSTANCES

1 and 2. *Na. M.C.P.A.* and *Na. D.C.P.A.*



Both are very similar in their effect on weeds and are toxic both to annual and perennial weeds. A large range of weed species have been killed at about 0·2% concentration used at a rate of 2 lb. per acre. With some species one compound is superior to the other but the differences between them are not large. In England M.C.P.A. is used more extensively than D.C.P.A. and has been found more selective for certain species while in America D.C.P.A. is the more popular, probably because of its more economic production in that country. The acids are relatively insoluble in water but their sodium and ammonium salts are soluble. They are also available in certain other forms, viz., Amine salts, which are highly water soluble and the esters which are dissolved in oil and then emulsified with water. They are generally slower in their action compared with other herbicides. The present cost of these herbicides in England is about 16 shillings a pound for M.C.P.A. and 10 to 12 shillings a pound for D.C.P.A.

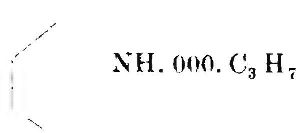
3. *Trichloro-phenoxy-acetic acid*



Little information is yet available as to its herbicidal effect on weeds and experimental work is still going on. In America it has been used for control of brush and other woody species. On many weed species it has been found as active as M.C.P.A. and D.C.P.A. but it is also toxic to certain species, particularly woody species, which have proved resistant to these other two chemicals. It is relatively insoluble in water and although the sodium salt is soluble it is still not as soluble as the salts of M.C.P.A. and D.C.P.A. The amine salt is highly soluble. About 0·2 per cent solutions have been found effective against weeds. It is not commercially available at present.

ARYL CARBAMIC ESTERS

1. *Iso propyl-N-phenyl-carbamate*



At first this was considered very promising because of its toxicity to grasses and not to dicotyledonous plants but, as already described in the text, this has not been confirmed and as such it has never been widely used. It is probably more readily absorbed by roots than the aerial parts. Though meristems in general are affected usually no effect is visible on leaves when applied as a foliage spray. In some cases it has been successful in controlling wild oats (*Avena fatua*) and couch grass (*Agropyron repens*) but it has to be applied when the grasses are very young, probably just when they are germinating. It is considered to be dissipated quickly in the soil. An average application for the control of grasses is considered to be about 10–20 lb. per acre but more may be required.

VAPORIZING OILS

1. *Esso vaporizing* (Anglo-American Oil Company Ltd.)

   Sp. gravity 0·7884 ; initial B.P. 161·5°C ; final B.P. 197·5°C ; aromatic content 16·6 per cent.

2. *Regent vaporizing* (Regent Oil Company Ltd.)

   Exact figures not available.

Both these vaporizing oils give a good kill on a wide range of young weeds and grasses, e.g., annual meadow grass (*Poa annua*), chickweed (*Stellaria media*), speedwells (*Veronica* spp.), fat hen (*Chenopodium album*), dead-nettle (*Lamium amplexicaule*), shepherd's purse (*Capsella bursa-pastoris*), yellow charlock (*Sinapis arvensis*), etc., which are some of the most troublesome weeds in forest nurseries. No difference has so far been shown by the two vaporizing oils in their toxicity to different weeds.

WHITE SPIRITS

1. *Shell T.P. 711* (Shell Petroleum Company Ltd.)

   Sp. gr. 0·780; initial B.P. 150°C; final B.P. 204·5°C; aromatic content 17·8 per cent.

2. *Anglo-Iranian white spirit WS 72* (Anglo-Iranian Oil Company Ltd.)

   Sp. gr. 0·780 ; initial B.P. 147°C ; final B.P. 210°C ; aromatic content 16·9 per cent.

3. *Varsol* (Anglo-American Oil Company Ltd.)

   Sp. gr. 0·7884 ; initial B.P. 161·5°C ; final B.P. 197°C ; aromatic content 16·6 per cent.

These three white spirits have been known to give a moderately good kill of weeds but not quite as good as the vaporizing oils. Little difference has been observed in the toxicity of these three oils towards weeds.

HEAVIER OILS

1. *Diesel oil* (Regent Oil Company Ltd.)

   All the oils described above come under the category of light oils whereas diesel oil is one of the heavy oils. Its boiling range is 200–360°C and aromatic content 20%. It is highly toxic to weeds but has little selective activity.

EXTRACTS

1. *Extract No. WS/395* (Anglo-Iranian Oil Company Ltd.)

   This is a petroleum extract with a boiling range from 100–200°C and is a fraction of the aromatic extract (B.R. 90–160°C) produced in the process of refining petroleum with SO_2. Its sp. gr. is ·8195 and aromatic content 69·5 per cent.

Little is known about its effect on weeds. During 1949 some spraying on mustard was done by the Agriculture Research Council, Oxford, and a 50% solution was found to kill it completely.

2. *Extract No. W8/409* (Anglo-Iranian Oil Company Ltd.)

This is a kerosene extract and is produced in the process of refining kerosene with SO_2. Its sp. gr. is 0·8675 ; B.R. 157–267°C and aromatic content 73·2 per cent.

There is as yet little information about its toxicity to weeds. Some spraying trials on mustard during 1949 showed that the highest concentration (25%) used in the experiments badly damaged the seedlings but did not kill many.

3. *Shell H-10* (Shell Petroleum Company Ltd.)

This is also a kerosene extract. Sp. gr. 0·925 ; initial B.P. 224°C ; final B.P. 290°C ; and aromatic content 85 per cent.

Little work has so far been done on its toxicity to weeds, but Digboi which is a similar extract has been known to kill a wide variety of common weeds in England at a concentration of 20–25% extract in kerosene and hence this is expected to have a similar effect.

4. *Extract No. W8/404* (Anglo-Iranian Oil Company Ltd.)

This is a lubricating oil extract and is very heavy. Nothing is so far known about its effect on weeds but, as it has a high aromatic content, it is expected to be very toxic to weeds.

Odourless kerosene (Shell Petroleum Company Ltd.)

This was used as a diluent for the extracts. Its aromatic content is only 0·5 per cent and is almost non toxic to weeds, hence its use as a diluent. Its sp. gr. is 0·795 ; initial B.P. 198°C ; and final B.P. 269°C.

APPENDIX II

(GRAPHS 1–12)

Graph 1. The toxicity of Na. M.C.P.A., Na. D.C.P.A., T.C.P.A., and I.P.C. to the germination of *Pinus sylvestris.*

Graph 2. The toxicity of Na. M.C.P.A., Na. D.C.P.A., and T.C.P.A. to the germination of *Pinus banksiana.*

Graph 3. The toxicity of Na. M.C.P.A., Na. D.C.P.A. and T.C.P.A. to the germination of *Pinus resinosa.*

Graph 4. The toxicity of Na. M.C.P.A. and I.P.C. to the germination of *Pinus contorta.*

Graph 5. The toxicity of Na. M.C.P.A. and Na. D.C.P.A. to the germination of *Pinus strobus.*

Graph 6. The toxicity of Na. M.C.P.A. and Na. D.C.P.A. to the germination of *Pinus attenuata.*

Graph 7. The toxicity of Na. M.C.P.A., Na. D.C.P.A. and T.C.P.A. to the germination of *Picea excelsa.*

Graph 8. The toxicity of Na. M.C.P.A. and Na. D.C.P.A. to the germination of *Acacia modesta.*

Graph 9. The toxicity of Na. M.C.P.A., Na. D.C.P.A. and T.C.P.A. to the germination of *Acacia catechu.*

Graph 10. The toxicity of Na. M.C.P.A. to the germination of the various species.

Graph 11. The toxicity of Na. D.C.P.A. to the germination of the various species.

Graph 12. The toxicity of T.C.P.A. to the germination of the various species.

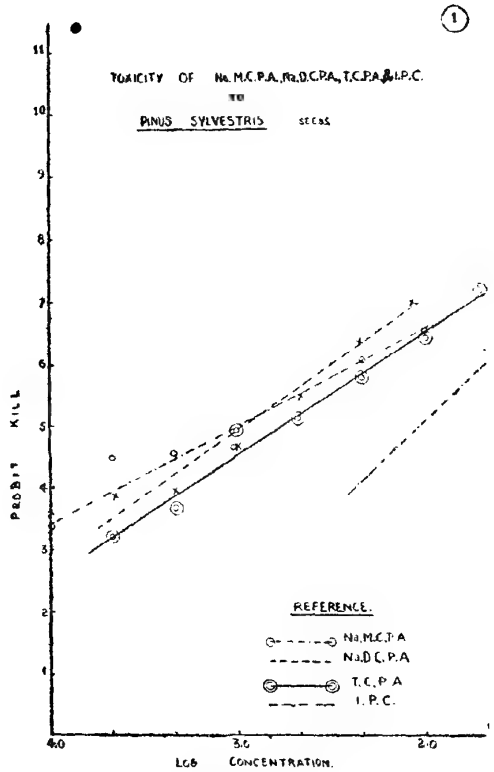
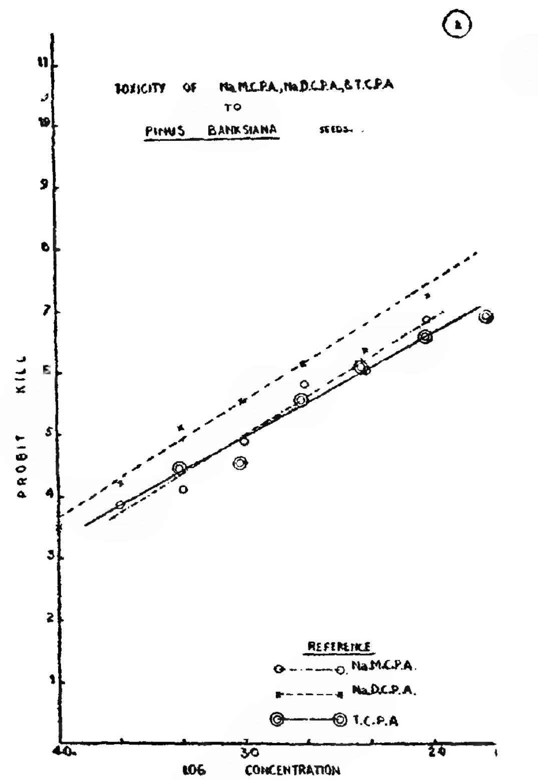


PLATE 1



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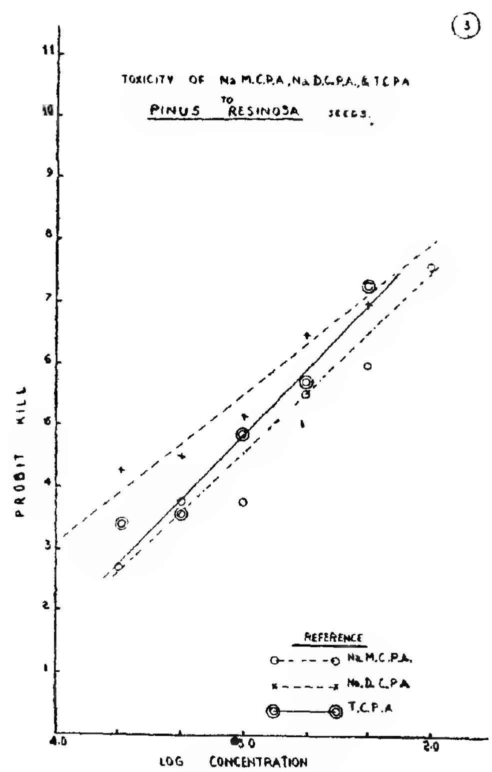

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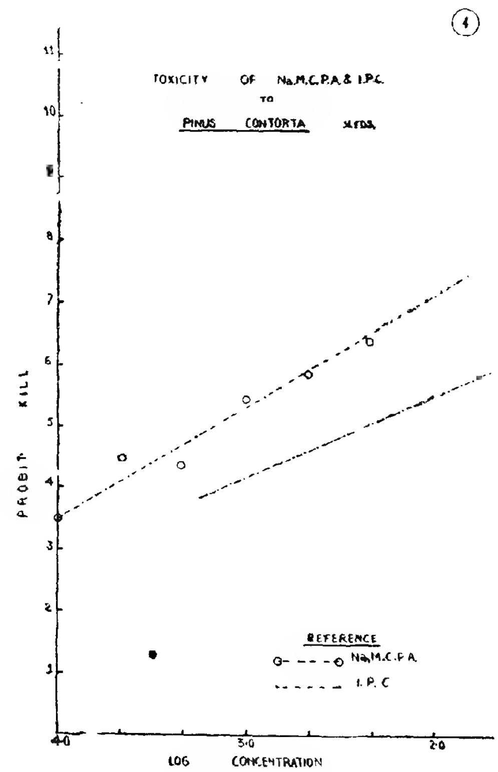

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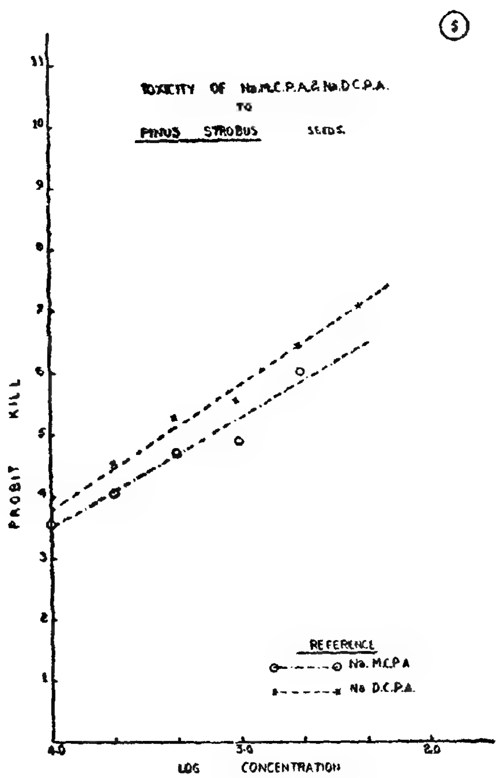

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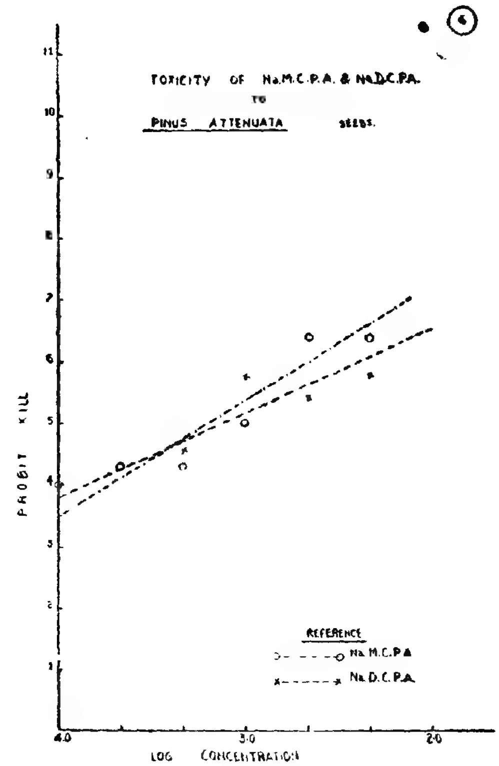

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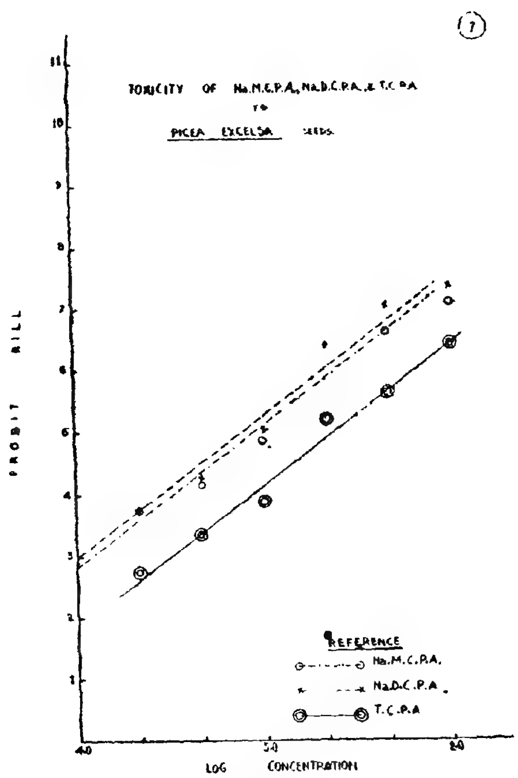

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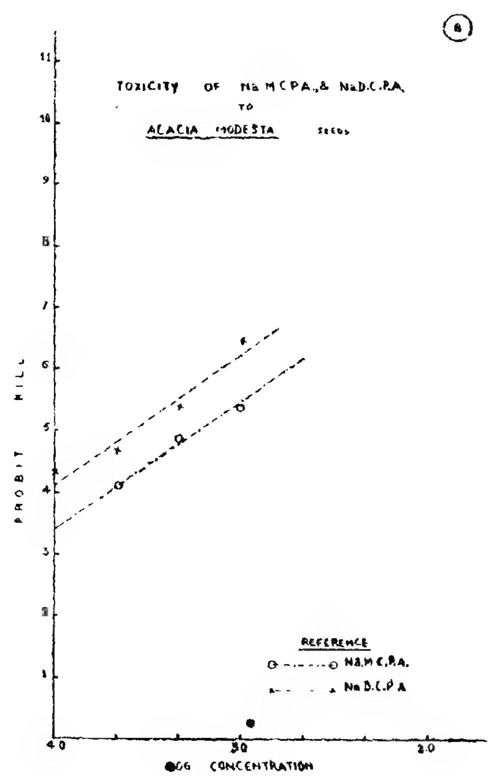

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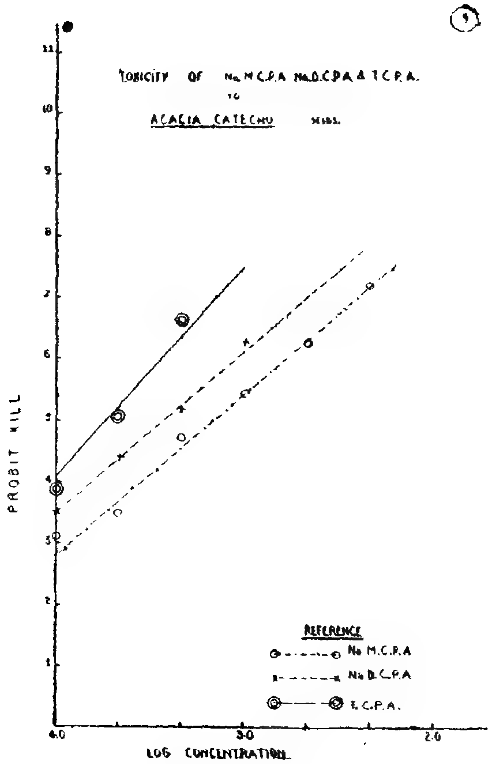

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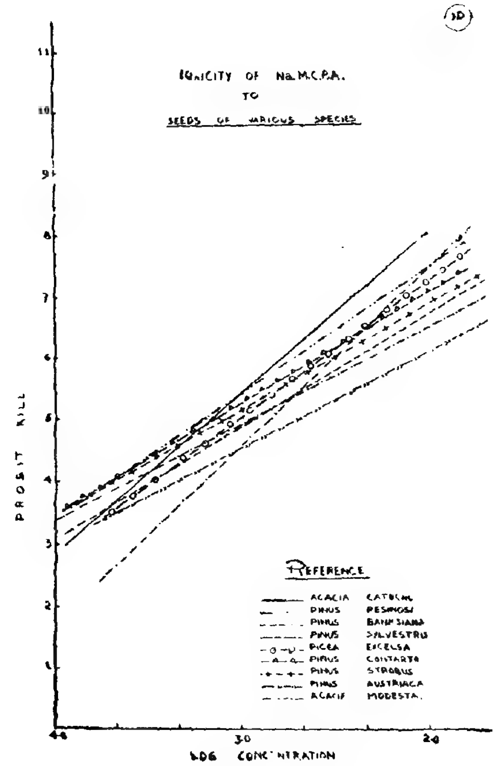

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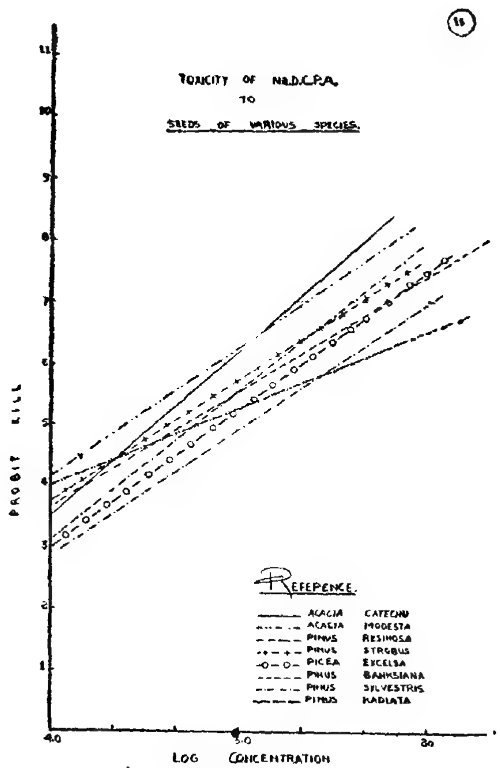


PLATE 11

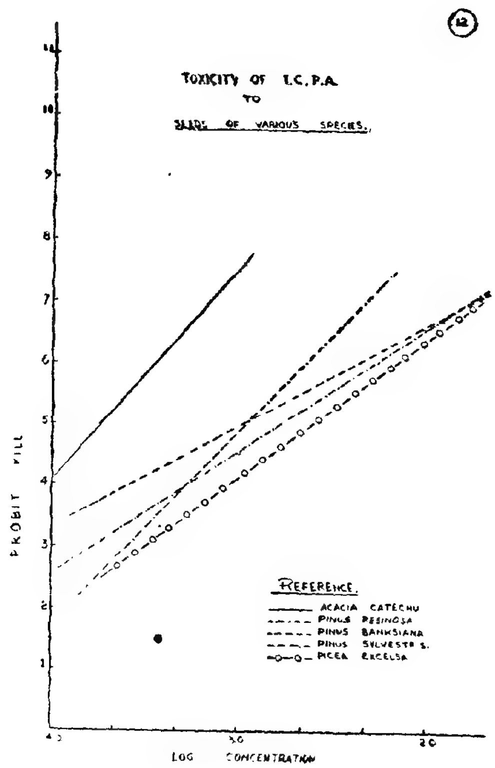


PLATE 12

APPENDIX III

The relative efficiency of different herbicides in the selective control of weeds
(Extract from Blackman 1946 and records of the Agricultural Research Council, Oxford)

Weed species		Concentrations of material per 100 gallons of spray solution per acre					
Scientific Name	Common Name	B.O.V. Acid gal.	Copper chloride lb.	D.N.O.C. lb.	M.C.P.A. lb.	D.C.P.A. lb.	Digboi, varsol and vaporizing oils
Agropyrum repens ..	Couch grass ..	?	?	R	R	R	T
Alchemilla arvensis ..	Parsley Piert. ..	(13W)***	R	(5–7)***	R	?	?
Alopecurus myosuroides	Black grass ..	R	R	R	R	R	?
Anthemis cotula ..	Mayweeds ..	13W*	R	6–8***	R	R	?
Arrhenathrum elatius ..	Tall oak grass ..	?	?	?	R	R	***
Atriplex patula and *A. hastata*	Goosefoot or Orache	12W**	R	6 8***	2·0*	(2·0)*	?
Avena fatua ..	Wild oat ..	R	R	R	R	R	?
Capsella bursa-pastoris	Shepherd's purse ..	10W***	(30)**	8***	2·0***	2·0***	*
Centaurea cyanus ..	Cornflower ..	(13W)*	R	(8W)**	(2·0)***	?	?
Cerastium spp. ..	Mouse-ear chickweed	?	?	?	?	?	**
Chenopodium album and *C. ficifolium* ..	Fat hen ..	12W**	R	6–8***	2·0**	2·0**	***
Chrysanthemum segetum	Corn marigold ..	13W**	R	8W***	R	R	?
Cirsium spp. ..	Thistles ..	?	?	T	2·0**T	2·0**T	?
Convolvulus arvensis ..	Field bindweed ..	?	?	T	2·0**T	2·0**T	?
Equisetum spp. ..	Horsetail ..	?	?	R	?	2·0**	?
Erigeron canadensis ..	Fleabane ..	?	?	?	?	?	?
Erysimum cheiranthoides	Treacle mustard ..	10***	20***	5–7***	1·5***	1·5***	?
Fumaria officinalis ..	Fumitory ..	R	R	6 8W***	R	(R)	?
Galium aparine ..	Cleavers ..	10***	20–30*	6–8**	R	R	?
Galeopsis tertrahit ..	Hemp nettle ..	10***	20–30**	6–8***	(2·0)**	?	?
Matricaria chamomilla	Chamomile ..	13W*	R	6–8***	R	R	?
Matricaria inodora ..	Mayweeds ..	13W*	R	6–8***	R	R	?
Papaver rhœas ..	Corn poppies ..	R	R	6 8***	2·0*	(2·0)*	?
Plantago spp. ..	Plaintains ..	?	?	?	2·0***	2·0***	?
Poa annua ..	Annual meadow grass	?	?	R	R	R	***
Polygonum aviculare ..	Knotgrass ..	13W***	R	8*	R	R	*
P. convolvulus ..	Bearbind ..	10***	20–30***	6·8**	2·0*	2·0*	*
P. persicaria ..	Willow weed ..	13W**	20 30*	8*	R	R	?
Ranunculus arvensis ..	Corn buttercup ..	13*	R	8*	1·5–2·0***	2·0***	?
R. repens ..	Creeping buttercup	?	?	?	2·0***	2·0***	?
Raphanus raphanistrum	White charlock ..	13**	20 30**	8**	2·0***	2·0***	?
Rumex spp. ..	Docks ..	?	?	T	T	T	?
Sagina spp. ..	Pearlwort ..	?	?	8**	2**	2**	**
Scandix pectenveneris ..	Shepherd's needle ..	15*	R	8*	2·0***	2·0***	?
Senecio vulgaris ..	Groundsel ..	?	?	?	?	?	?
Sinapis arvensis ..	Yellow charlock ..	7–10**	10 15***	6***	1·0***	1·0***	*
Sonchus spp. ..	Sowthistle ..	?	?	?	?	2·0**	R
Spergula arvensis ..	Spurrey ..	10***	20*	6·8W**	2·0*	2·0*	**
Stellaria media ..	Chickweed ..	13**	R	8*	R	R	**
Taraxacum officinale ..	Dandelion ..	?	?	?	2·0**	2·0**	T
Thlaspi arvense ..	Pennycress ..	7***	15***	4–6***	·75***	(1·0)***	?
Urtica urens ..	Annual nettle ..	10W***	(R)	6–8**	(2·0)*	?	?
Veronica agrestis *V. hederæfolia* ..	Speedwells ..	10***	20**	6 8**	R	?	?

KEY.— *** = Over 90% kill expected.
** = Over 80% „ „
* = Over 50% „ „
R = Resistant.
W = Wetting agent should be added to spray solution.
T = Tops killed.
( ) = Figures are tentative.
? = Information is not yet available.

APPENDIX IV

A.—Reactions of young tree seedlings to 2, 4 D and 2, 4, 5 T formulations when applied as foliage spray

(Extract from Fifth Annual North Central Weed Control Conference Research Report 1948)

Scientific Name	Common Name	Formulations and Concentrations 2, 4-D	Formulations and Concentrations 2, 4, 5-T
Acer negundo	Elder	II (Ester ·2%)	
Acer rubrum	Maple, red	III (Ester ·3%)	
Acer saccharum	Maple, sugar	III (Ester ·3%)	III (Ester ·15%)
Ailanthus glandulosa	Tree of heaven	I (Esters ·3%)	
Betula nigra	Birch, river	I (Conc. E & S)	
Corylus spp.	Hazel	II (Ester ·2%)	
Fraxinus spp.	Ash	IV (Ester ·2%)	III (Ester ·15%)
Fraxinus americana	Ash, white	IV (Ester ·3%)	
Juglans cinerea	Walnut, white	I (Ester ·3%)	
Juglans nigra	Walnut, black	III (Ester ·3%)	
Lirodendron tulipifera	Tuliptree	I (Ester ·3%)	
Pinus tæda	Pine, loblolly	I (Amm. salt ·45%)	
Plantanus occidentalis	Sycamore	I (Conc. Esters and salts)	
Populus deltoides	Cotton wood	II (Ester ·3%)	
Populus balsamifers	Poplar, black	II (Esters 1½ lb.)	
Populus tremuloides	Poplar, white (aspen)	II (Ester 1½ lb.)	
Populus spp.	Poplar	II (Ester 1½ lb.)	
Prosopis juliflora	Mesquite	III (Ester ·2%)	III (Ester ·2%)
Prunus augustifolia	Plum, sand	I (Ester ·2%)	I (Ester ·2%)
Prunus serotina	Cherry, wild	I (Ester ·3%)	I (Ester ·15%)
Quercus alba	Oak, white	III (Ester ·3%)	I (Ester ·15%)
Quercus imbricaria	Oak, Laurel	III (Ester ·3%)	
Quercus macrocarpa	Oak, bur	III (Ester 1½ lb.)	
Quercus muhlenbergii	Oak, dwarf	II (Ester ·2%)	II (Ester ·2%)
Quercus marilandica	Oak, black jack	II (Ester ·2%)	II (Ester ·2%)
Quercus rubra	Oak, red	III (Ester ·3%)	
Quercus stellata	Oak, post	II (Ester ·2%)	II (Ester ·2%)
Sambucus canadensis	Elder, common	I (Ester ·15%)	
Salix spp.	Willow	I (Ester or Amine ·2%)	
Salix lasiandra	Willow, bright	..	I (Amines ·15%)
Salix nigra	Willow, black	II (Ester ·2%)	II (Ester ·2%)
Ulmus spp.	Elm	I (Ester ·3%)	
Ulmus americana	Elm, American	III (Ester ·2%)	I (Ester ·15%)
Ulmus alata	Elm, winged	III (Ester ·2%)	II (Ester ·2%)
Ulmus japonica	Elm, Jap	I (Ester ·2%)	
Ulmus pumila	Elm, Chinese	..	II (Salts and Ester ·1%)

KEY.— I (hypersensitive) = Plants that are killed by one application of the chemical.
II (sensitive) = Plants which react to the chemical and may be killed by repeated applications.
III (semi-tolerant) = Plants which react to the chemical but are not killed even by repeated applications.
IV (tolerant) = Plants which show negligible reaction to the chemical.

B.—*Reactions of young coniferous seedlings to different selective herbicides*
(Results summarized by the Agricultural Research Council, Oxford)

Scientific name	Common name	Concentration of material per 100 gallons of spray solution per acre: Na.M.C.P.A. 2 lb.	Na.D.C.P.A. 2 lb.	D.N.O.C. 4 lb.	Mineral oils: Varsol	Mineral oils: 10% Digboi in odourless kerosene	E.P.C. 10 lb.
Larix Kæmpferi ..	Japanese larch	S	R	S	S	R	S
Larix europæa ..	European ,,	S	S	S	—	—	—
Pinus sylvestris ..	Scots pine	R	—	R	—	—	—
Pinus austriaca ..	Austrian pine	R	—	R	R	—	—
Pinus nigra var. corsicana	Corsican pine	S	S	S	R	R	S
Picea sitchensis ..	Sitka spruce	R	—	S	—	—	—
Pseudotsuga taxifolia ..	Douglas fir	R	R	S	S	R	S

KEY.—R = Resistant.
S = Susceptible.
— = Not tried.

C.—Beatty and Jones (1945) have reported that the seedlings of the following plants, when sprayed with weedone (a commercial form of 2, 4–D) at a rate of 1 part weedone in 100 parts of water and at 75 lb. pressure, remained uninjured while many weeds were killed.

UNINJURED PLANTS

1. *Pinus strobus* (White pine).
2. *Pinus nigra forma austriaca* (Austrian pine).
3. *Pinus montana mughus* (Swiss pine).
4. *Taxus cuspidata* (Japanese yew).
5. *Sambucus racemosa* (Golden elder).
6. *Buxus sempervirens* (boxwood).
7. *Rhododendron* (hybrid).
8. *Tsuga canadensis* (hemlock).
9. *Juniperus pfitzeriana*.
10. *Juniperus sabina*.
11. *Juniperus hibernica* (Irish Juniper).

AGAR OIL FROM THE WOOD OF *AQUILARIA AGALLOCHA* ROXB.

BY SADGOPAL AND B. S. VARMA

Chemistry of Forest Products Branch, Forest Research Institute and Colleges, Dehra Dun.

ABSTRACT

A simple and economic method of distilling the essential oil of agar from the infected wood of *Aquilaria agallocha* Roxb. has been developed. The process can be worked as a profitable cottage scale industry. Details of the distillation plant and accessories as well as processing are indicated. Yield percentages of agar oil from various grades of wood and their physical constants have been recorded. Preparation of highly concentrated attars under the new technique has also been shown to yield better quality at lower cost.

The paper incidentally summarises the present day knowledge regarding the factors responsible for the attack of sound agarwood by certain fungus and the consequent development of the agar oleoresin.

Agar oil prepared by the new method has a true balsamic aroma with a woody back-note. Its high fixative value and exotic character will make an important addition to the list of Indian essential oils of great odour appeal.

The manufacture of agar attars and perfumes like that of sandalwood oil has been a very ancient and profitable industry in India. The wood from which the valuable perfume is obtained, is the scented wood of *Aquilaria agallocha* Roxb. a large evergreen tree, distributed only on the north-eastern border districts of India, particularly in the hill forests of Khasia, Garo, Naga, Cachar and Sylhet. Locally, the tree is known as *Sasi*. Sound wood from the green tree exhibits no odour. Agarwood, which is odoriferous, consists of irregular patches of dark streaks, highly impregnated with an oleoresin due to a certain fungus infestation, and is found in the interior of comparatively old and mature trees. On account of the resinous deposition, such patches of wood become heavier than water and are known as *Agar* or *Agaru*.

PLATE I

The dark patches in the wood indicate the formation of agar resin.

What causes the oleoresin to be deposited is still shrouded in mystery, but according to Gamble[1] "It is found in fragments of various shapes and sizes in the centre of the tree, and usually, if not always, where some former injury has been received". From outward appearance, there is, however, no indication as to whether a tree contains agar. Professional agar collectors among the *Garos* (a hill tribe) are able to spot out agar-bearing trees successfully. Unskilled labour generally employed for the purpose, however, cuts the trees indiscriminately and chops them into pieces to sort out any agarwood. The agar contractor thus loses money searching for this product while the Government loses many valuable trees which would otherwise have served as mother trees and which might, perhaps, have developed *agar* in the later stages of their life.

The study of growth and development of agar in *Aquilaria agallocha* Roxb., was first undertaken in 1929 at the instance of the Assam Government. Tunstall[2] isolated three fungi

PLATE I

PLATE II

PLATE III

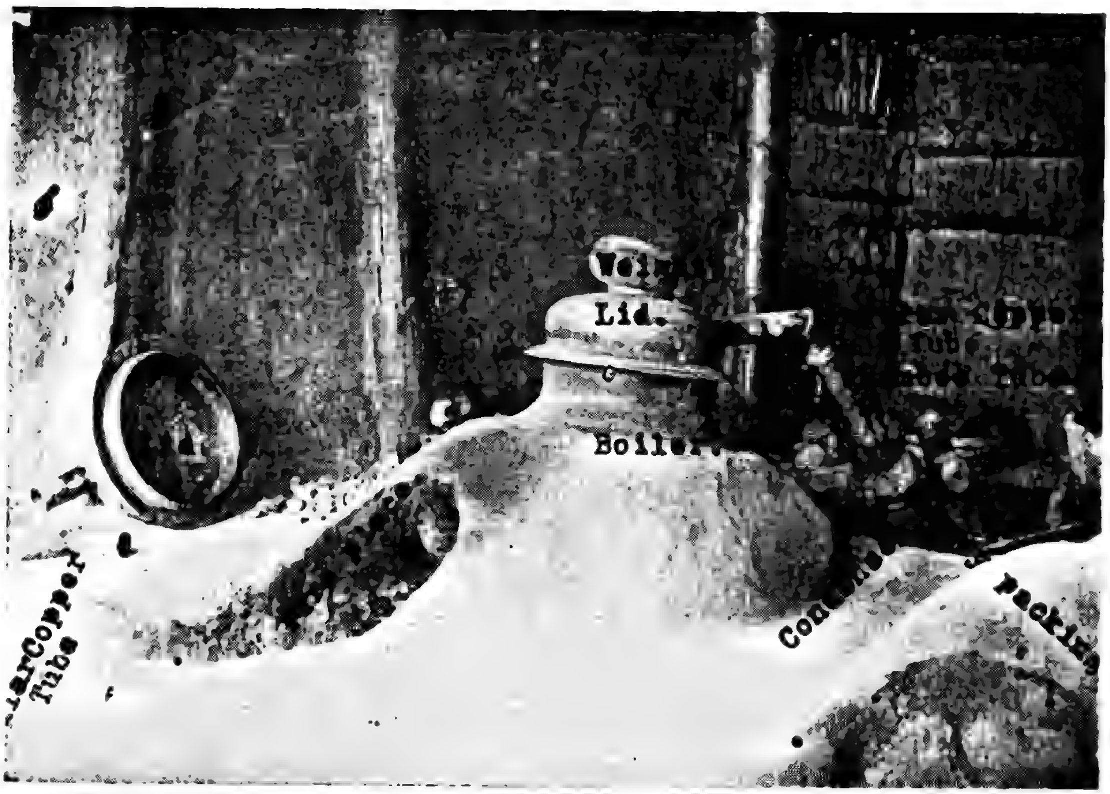


PLATE IV

from *agar*, namely (i) *Aspergillus* sp. (which is primarily responsible for the production of *agaru* in *A. agallocha* trees), (ii) *Penicillium* sp. and (iii) *Fusarium* sp. Some of the healthy trees were inoculated by him with *agaru* fungus (*Aspergillus* sp.) and positively hopeful results were reported as to the development of agar-infected wood. This work was later taken up by S. R. Bose[3]. He again inoculated about 36 trees with *Agaru* fungus in 1939–40 and 1941, and agar formation was traced in the inoculated regions of some of them. Borings taken within ¾ inch radius around the point of inoculation smelt strongly of agar but agar formation did not seem to have spread beyond this radius, as can be seen in Plate II.

PLATE II

The chemical studies conducted in this laboratory on the role of hydrolytic changes possible from any action on glucosidic bodies present in green and dry *sasi* wood, reveal that it is not possible to develop any agar oil or aroma by hydrolysis. Under the circumstances experiments originally started by Tunstall in the year 1929–30 and later confirmed by S. R. Bose since 1939 appear to be the only possible means of developing agar oil in otherwise uninfected wood. The mycological and anatomical studies now in hand at the Forest Research Institute are expected to throw further light on this point ultimately.

Agar is sold in the market in different forms such as Agar, Agar-batti Agardhup, Agar-attar (or agar oil).

(1) *Agar*.—The wood of the agar tree is white but the black-patches formed by resinous deposition are termed agar. The white wood is interspersed with these black patches. Sometimes it is merely streaks of black lines which are cut out from the rest and sometimes it is a big block. The classification of agar for the price is made according to the proportion and concentration of black substance in the wood. Watt[4] has classified agar into 3 classes (1) *Gharki*, which sinks in water and (2) *Samaleh*, which floats and (3) *Neem-Gharki* or *Samaleh-i-aala*, which partly sinks in water. These terms are not in use now and seem to have gone obsolete. At present the agarwood is classed into (1) real agar and (2) Dhum, from the word Do-anna (two annas), i.e., one-eighth. These are also classified as No. 1, No. 2, No. 3 and No. 4. The fourth quality, also containing dust, is the Dhum and is exclusively employed for distillation of agar perfume. Nos. 1 and 2 grades fetch higher prices and are exported as such.

PLATE III

The agar, as it comes in the market, is always coloured black with a solution of catechu and other substances[5]. The method is a trade secret, known to the people of two villages, Dakhinbhag and Dhaka-Dakhin. They would colour the inferior quality or even the Dhum to give it the appearance of good agar. The original object of the colouring was adulteration only but now even the best Agar does not fetch its real value unless it is coloured.

(2) *Agar-batti*.—These are small chips of Agar or Dhum, scraped and coloured, for being burnt as incense by Mohammadans, Hindus and chiefly by the Parsees.

(3) *Agar-Dhup*.—It is also used as incense like the Agar-batti. It is made by Mohammadans in Calcutta.

(4) *Agar oil or Agar attar*.—It is obtained by distilling the chips of Agar and Dhum by the wet process[6], which has been a prosperous industry in Assam since ages. The chips are

kept soaked in water for 3 or 4 days. These are then distilled, the chips are then pounded and again distilled. For distillation, the chips are put in a copper pot, called *Deg*, which serves as a still and is fixed permanently over a furnace (see Plate IV). The pot is filled with water sufficient to bring its level to within 6 inches of the top. A lid, called *Sarposh* is then fixed tight with clay and cowdung and a piece of stone is put on the lid to keep it pressed in position. On one side of it is provided a short copper tube about 1½ inches diameter and 5 inches long. To this tube is attached one arm of a removable bent delivery tube of a slightly smaller diameter, called *Kham*. To the other arm of this angled tube is attached a bamboo pipe, *Chungi* which leads into a copper pot called *Barupa* or receiver, the mouth of which is tightly packed with pieces of gunny bag to prevent the steam leaking out. The receiver is kept immersed in cold water in a jar called *Marna*, embedded in the earth. The operation is stopped when the pipe gets hot and steam begins to come out through the joints of the pipe with the receiver. The fire is removed and the pot left to cool. The attar which is floating on the distillate water is removed by hand.

PLATE IV

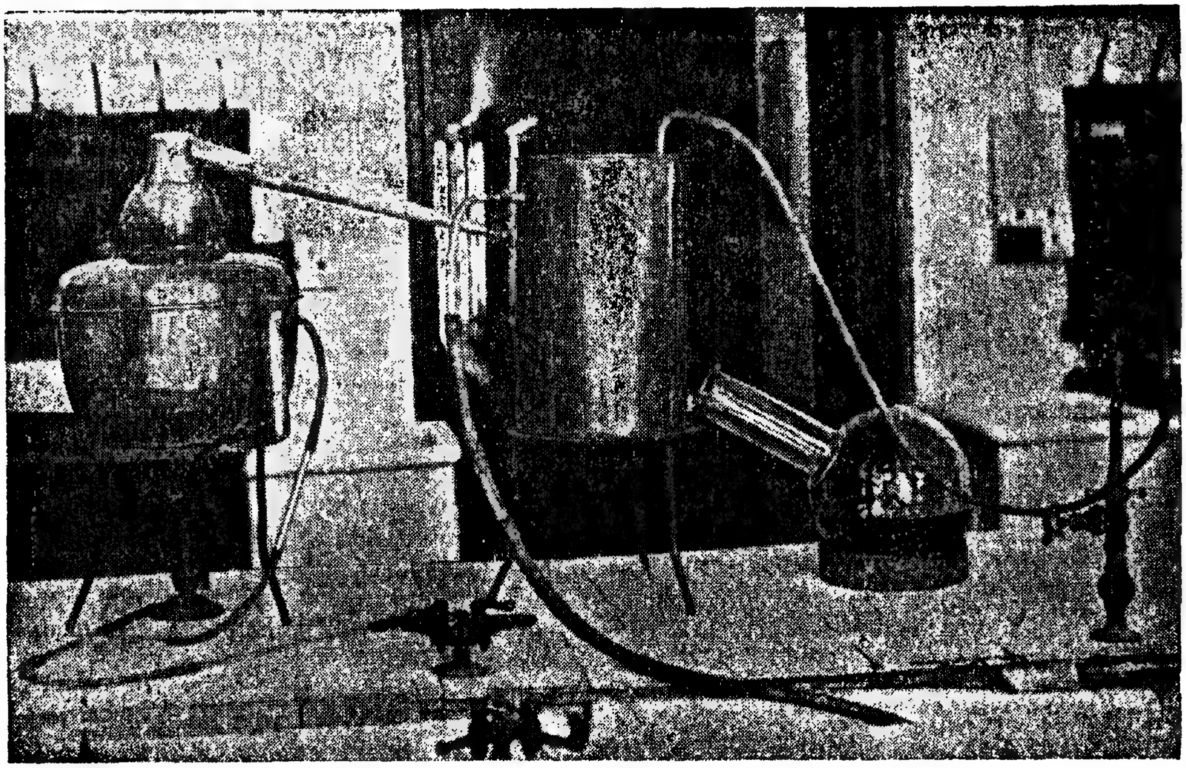
The attar is used as a scent, it is sometimes adulterated with other oils to make a cheap quality. It is sold by tolas, the price varying from As. 4 to Rs. 10 per tola* according to the degree of adulteration.

At present the indigenous manufacturers of this perfume are Pakistani nationals residing in certain villages in the Sylhet district of East Bengal bordering on the Karimganj Sub-division of Cachar district in Assam. The agar bearing wood is now transported to these border villages in East Pakistan where alone the distillation has been carried out in the past. The manufactured perfume is then re-exported to Calcutta and Bombay whence it finds its way to Arabia, Turkey, Persia, etc. Agar attar is highly prized in these countries. Among the many problems springing up due to the partition of the country into two sovereign states, the agar oil industry has also presented a problem of its own. Perfumery articles are subjected to a high import duty on entry into India, which adversely affects the revenue fetched by agar mahals by the Assam Forest Department. Attempts to shift the distillation activities to Assam areas were unsuccessful, as indigenous distillers are, as is usually the idea, conservative and superstitious and believe that unless the manufacture takes place in the traditional centres of distillation supposed to be sacred to some Muslim *Pirs*, the distillate will have no perfume.

The investigation for evolving a suitable process for the distillation of the oil has, therefore, been entrusted to the Forest Research Institute. Intensive experiments have been carried out to study the conditions favouring an economic recovery of the oil from agarwood. It was found that the wood contains a very viscous and heavy oil, which does not volatilize easily by ordinary steam treatment. Superheated steam under high pressure extracts the oil but the oil loses its agar odour. Under the circumstances an alcoholic extract of oil, resin, etc., was prepared from which the alcohol was removed by direct heat, leaving the oil, resin and other impurities. A 'concrete' was made from this extract treating the latter with mild alkali solution and then macerating with sulphuric ether. But again the 'concrete' was found devoid of the pleasant agar odour, which is naturally very faint. These findings are in conformity with the results obtained previously in this laboratory by Puran Singh[7]. These laboratory experiments indicate that it is much better to distil the oil with water vapours by boiling the wood powder in water or its alcoholic extract than to steam it under pressure.

* 39 tolas = 1 lb.

PLATE V



A question to be considered is, whether the manufacture of the perfume should be attempted in a centralized place in Assam where all the raw material could be transported and distilled, or whether it should be on a cottage industry basis. In the latter case, small portable distilling units would have to be installed in suitable centres in the forests. Much can be said for and against both the alternatives, but for the present we have mainly studied and evolved a process for use as a cottage industry. Without a complete picture of the transport arrangements and quantity of raw material available, large investment on a centralized unit would be hazardous and cannot safely be recommended.

DISTILLATION

The agarwood pieces are soaked in locally available clean water for 60–70 hours. They are then cut into smaller bits by a chopper and are further worked up into still smaller pieces by grinding in a hand mill or by husking. The finer the material, the better and more economical would be the yield of the oil. The following equipment is all that is required for the distillation :—

1. The retort or still made of copper or brass.
2. The condenser made of copper tubing.
3. The receiver for the condensate.

Besides the above, small items of equipment such as a Florentine flask, separating funnels and ordinary funnels, etc., are also essential.

1. *The Retort.*—In its simplest form the retort can be made out of a cylindrical container with a height slightly more than its diameter. Smaller units of 18″ × 21″ are usually obtainable

from local utensil shops, while a bigger unit can be made out of brass or copper sheets. Its rim is hammered out into a flange to form a suitable contact surface for the cover. A support ring made of 1½" angle-iron is fastened outside and around the retort just under the flange, with one face giving support to it. To another iron ring under this support ring, are fixed three long iron rods to form a tripod stand for the still. A false bottom, made from brass sheeting, perforated with many small holes and rounded according to the size of the still, is inserted inside the latter, 2"–3" above the real bottom. The retort is provided with a removable lid made of sheet metal similar to that of the retort, in the centre of which is soldered a swan-neck, 4" in diameter and tapering towards its end. The lid is strengthened and ringed with strap iron metal. To the lid is also soldered a narrow metal tube 3" to 4" long and ½" in diameter. This tube is kept corked when the distillation is going on and is used only for adding more water to the charge without removing the lid. The retort is well insulated by masonry work to conserve heat.

2. *The Condenser.*—The second major part of the distillation equipment is the condenser, which serves to convert all the steam and the accompanying oil vapours into liquid. It can be made of a 6 feet long copper pipe about 1 to 2 inches in diameter, immersed horizontally in a shallow tank, with a definite slope towards the cool end to ensure adequate drainage of the condensate. The tank can be made out of a wooden box of requisite dimension, in which cold water is made to run from end to end and cool the copper tube.

3. *The Receiver.*—The third essential part of the distillation equipment consists of the condensate receiver and oil separator. This is made of a special design commonly called Florentine flask. The condensate flows from the condenser into the flask where the distillation water and the volatile oil separate. It is usually made of glass but can be made of copper or other metal. As the distillation water increases in the flask, it flows out through the side tube, while the oil remains floating undisturbed on the top. The whole unit when assembled is shown in figure 6.

PLATE VI

Procedure.—The retort is seated in an oven or *bhatti*, with its weight resting on the tripod legs. The *bhatti* is provided with a chimney sufficiently high to keep a draught running through.

A charge of thoroughly comminuted wood is put in the retort over the grid and soaked overnight in water 6–8 times the weight of the charge. Common salt on the basis of 5 per cent on the quantity of water is also added on to it. Next day some more water is added if required, so that it stands 3 to 4 inches above the charge leaving, however, ample vapour space above to avoid boiling over and carrying over of spray into the condenser. The cover is then tightly fastened with the help of 5 or 6 external clamps, using a suitable gasket between the cover and the retort to avoid leakage of vapours at the joint. The swan-neck is connected to the condenser and the cooling water permitted to flow through the tank. The fire is then lighted.

Once the charge has reached its boiling point, condensate will begin to issue from the open end of the condenser and is allowed to run directly into the separator which is previously filled with water. The rate of distillation can be controlled by the intensity of the fire. Avoiding over-boiling, the rate of distillation must be adjusted near about the maximum in order to obtain the efficient production of oil.

Agar oil is a very high-boiling oil and, therefore, the proportion of oil to water in the condensate is very small. Moreover, agar oil contains its most valuable constituents in the last runs. For all these reasons, for complete winning of the oil the distillation has to be prolonged for about 30 to 32 hours.

Treatment of the distillation water.—To carry on the distillation for 32 hours, water in the retort must be replenished very often. Instead of doing it with fresh water the separated

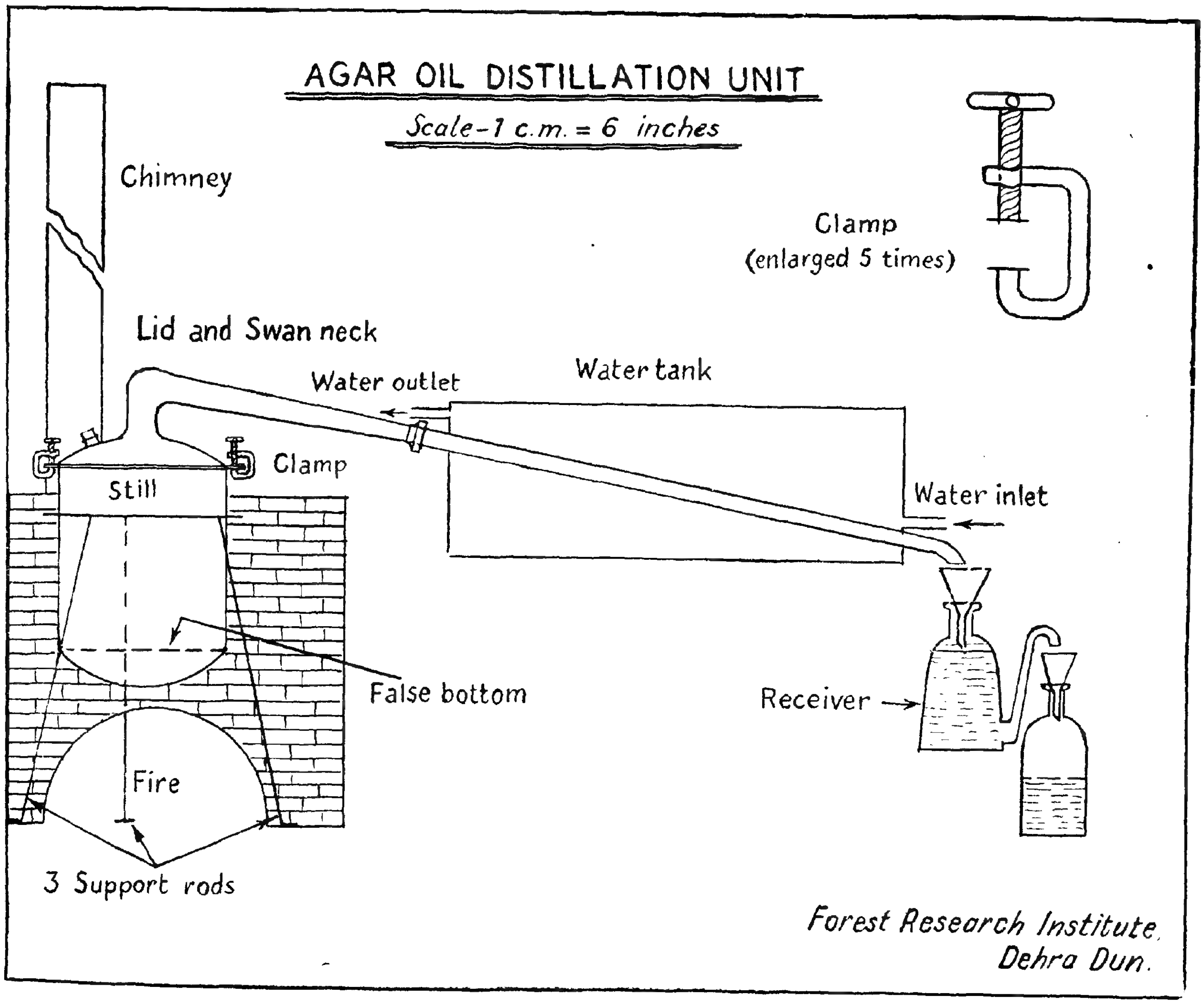

AGAR OIL DISTILLATION UNIT
Scale-1 c.m. = 6 inches
Chimney
Clamp
(enlarged 5 times)
Lid and Swan neck
Water outlet
Water tank
Clamp
Still
Water inlet
False bottom
Receiver
Fire
3 Support rods
Forest Research Institute,
Dehra Dun.

PLATE VI

distillation waters decanted free from the oil are employed for the purpose. The distillation waters flowing off the oil separator, contain some of the oil in solution or in suspension as is indicated by the milky appearance and are of extremely bitter taste. Such distillation waters are not discarded but are returned back to the retort from time to time during the distillation through the tube provided in the lid of the retort for this purpose.

Recovery of the oil.—The last collection of the distillation water in the receiver after the distillation is over, is saturated with common salt and transferred to a separating funnel together with the oil. The latter is then extracted with sulphuric-ether. This is usually done twice. The drawn off and mixed solvent solutions are then concentrated in a glass flask by driving off the solvent first by distilling at atmospheric pressure and later on in vacuum, until every trace of the solvent is eliminated from the oil. If no vacuum pump is available, the last traces of the solvent can be removed by keeping the oil on a water bath for sometime, and passing a mild stream of air through, for a while.

Economics of the distillation.—As distillation takes about 32 hours, it is advisable to run it as a continuous operation day and night by shift arrangement of the labour, instead of distilling for 8 to 10 hours a day and restarting the next day. If the distillation is carried on from the start to the finish for 32 hours at a stretch, there will be a great economy of fuel, and a better recovery of the oil. The liberated oil vapours condense and fall back in the still if the distillation is stopped in the middle after 8 or 10 hours, which would mean the redistillation of the liberated oil with extra labour and expense.

Similarly, if instead of one still, a battery of four stills is installed, one man can safely look after these four. In this way four men, each working 8 hours a day by turn can attend to four distillations going on simultaneously.

Yield percentage and quality of the oil.—The yield of agar oil, like that of any other essential oil, naturally depends upon the quality or the grade of raw material employed. It has been reported to vary from 0·31 to 1·51 per cent[8]. Puran Singh[7] obtained a yield of 3·09 per cent in selected black portions and 0·53 per cent in the pale bulk. According to De and Adhikari[9] it varies from 0·75 per cent to 2·50 per cent. For our present work, agarwood received in this laboratory was divided into 8 different grades according to depth of colour and appearance. The moisture content has been found to vary between 10–12% of the wood. The yield of oil and its physical data, from all these grades are tabulated below :—

TABLE I

Quality of Agarwood	Yield of oil %	Colour of the oil	Specific gravity at 25°C	Refractive index at 25°C
1. Yellow wood ..	0·09	Light yellow	..	1·4940
2. Wood dust ..	0·15	Dark brown	0·9934	1·4841
3. Brownish wood ..	0·23	do.	1·0075	1·5030
4. Dhumwood				
(a) Water distilled for 30–32 hours ..	0·40	Yellowish	1·0116	1·4920
(b) Steam-distilled for 12 active hrs. at 40–45 lbs. p.s.i. ..	0·102	Yellowish brown	0·9880	1·4878
(c) The same material water-distilled for further 10 hours ..	0·06	do.	0·9457	1·4898

(*contd.*)

TABLE I—(*concld.*)

Quality of Agarwood	Yield of oil %	Colour of the oil	Specific gravity at 25°C	Refractive index at 25°C
(*d*) The mare from above gave in a laboratory test 0·22% more of oil				
5. Superior Dhumwood ..	0·84	Yellow	..	1·4866
6. Superior brownwood ..	1·11	Brownish yellow	1.0080	1·4948
7. Superior blackwood ..	1·91	Brown	1·0118	1·5012
8. Absolutely black agar (heavier than water) ..	2·19	Brown	1·0118	1·5020

Agar oil is a very thick oil of golden yellow to yellowish brown colour, having a characteristic balsamic odour and a pleasant and mild aroma of its own. As tabulated above, the Dhum, which is the main bulk of agarwood and usually exclusively employed for the recovery of agar oil, gave a yield 0·4 per cent of the oil, with specific gravity of 1·0116 and refractive index of 1·4920 at 25°C and an optical rotation of —14°.

Leading essential oil chemists and manufacturing houses in U.K. and U.S.A., to whom samples of this oil were sent for opinion, have all appreciated it for its characteristic balsamic odour and high fixative properties. These samples have resulted in pressing enquiries both from India and abroad for arrangements to be made for regular and commercial supplies of this important oil.

Agar attars.—Hitherto the indigenous manufacturers do not appear to have distilled the pure essential oil of agar. They only prepare agar attars using sandalwood oil, vegetable oils and even liquid paraffin as bases, in which form the perfumes are generally used in oriental countries. *Attars* are not standard products and their quality and value depend upon the nature of the base employed and the amount of aromatic oil distilled into it. Seven different grades of agar attars from reputed manufacturers were obtained for examination, which gave the following results :—

TABLE II

No.	Grade	Quoted prices per tola	Refractive index at 25°C	Solubility in 90 per cent alcohol
1	A	Rs. 10/-/-	1·5053	Soluble
2	B	,, 3/4 -	1·4904	Insoluble
3	B	,, 3/-/-	1·4980	do.
4	C	,, 1/2/-	1·4820	do.
5	C	Re. 1/-/-	1·4818	do.
6	D	As. -/12/-	1.4776	do.
7	E	,, -/4/-	..	..

In order to produce similar products to meet the large demands from consumers of *attars*, two qualities of agar attar, one based on the pure East Indian sandalwood oil and the

other based on the high-boiling sesquiterpenes of sandalwood oil, were prepared. These attars possess a sweet, well-rounded agar aroma and are cheaper to produce. Their characteristics are tabulated below :—

TABLE III

	Specific gravity at 25°C	Refractive index at 25°C	Optical rotation
Agar attar on sandalwood oil as base ..	0·9847	1·5001	−16·2°
Agar attar on sesquiterpene base ..	1·0086	1·4999	−3·2° (in 10% alcoholic solution)

Both the products have been highly appreciated for æsthetic uses and for scenting tobaccoes, betal leaves, etc.

CONCLUSION

Experiments conducted at the Forest Research Institute have not only established the clear possibilities of carrying out economic distillation of agarwood to meet the demands of the perfumery industry with profit but have also shown the potentiality of developing a decent foreign trade in a new essential oil, the raw material for which is mainly a monopoly of India at present. It is hoped that necessary arrangements will soon be completed for its commercial exploitation by the Assam Government and before long a new and an important addition will have been made to the list of essential oils.

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A NOTE ON THE GERMINATION OF SEEDS OF INDIAN BELLADONNA

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Germination of the seeds of *Atropa belladonna* Linn. has been studied in Europe and the U.S.A. where the germination time is four to six weeks. This period has been shortened by pre-treatment of the seeds with high concentrations of sulphuric acid for short duration. In India where *Atropa acuminata* Royle grows wild in the North-Western Himalayas, little work has been reported on the germination of its seeds.

Experimental Work.—Two nurseries were prepared to study the germination of *Atropa acuminata* seeds with a view to transplanting the seedlings in a Drug Farm on a commercial scale.

In one of the nurseries at Srinagar 5,000 ft. above sea-level, *Atropa acuminata* (Indian Belladonna) collected from the plants growing in a state of nature from the Kashmir forests were sown in well prepared and well manured flat seed beds in March 1950. The seeds were sown in lines and covered with a fine film of earth. The top surface was irrigated occasionally to keep the beds moist. Some of these seeds were pre-treated with different concentrations of sulphuric acid for varying lengths of time. After treating with sulphuric acid the seeds were washed with water and dried before sowing.

Some of these seeds were soaked in cold water for 24 hours and then dried before sowing. All these experiments were repeated. The results are tabulated in Table I.

TABLE I

Showing the time of germination of treated seeds of Atropa acuminata

Treated with sulphuric acid in concentration of	Duration of treatment in minutes	Germination period in days	REMARKS
5%	5	30	Germination very poor
5 ,,	10	..	No germination
5 ,,	20	..	.. ..
20 ,,	5	..	.. ..
20 ,,	10	..	.. ..
20 ,,	20	..	.. ..
40 ,,	5	..	.. ..
40 ,,	10	..	.. ..
40 ,,	20	..	.. ..
60 ,,	½	30	Germination fair
60 ,,	1	30	.. ..
60 ,,	2	30	.. ..
80 ,,	½	23	.. ..
80 ,,	1	23	.. ..
80 ,,	2	23	.. ..
90 ,,	½	27	.. ..
90 ,,	1	27	.. ..
90 ,,	2	27	.. ..
Soaked in cold water and dried before sowing	24 hrs.	30	.. ..
Control	..	30	.. ..

NOTE :—All the seeds were sown on 24th March 1950.

In another nursery at *Yarikah* 7,000 ft. above sea-level where the commercial cultivation is being carried on, the seeds were sown in June as the snow melts later in this area.

Flat seed beds were prepared and manured with farmyard manure. The seeds were sown broadcast in June and July and covered with a thin film of fine earth. As the day temperature rises to 90°F or more during the months of July and there are very few rains, the seed beds were shaded with green pine twigs for a number of days and sprayed with water frequently to keep them moist and cool. The night temperature was low. Seeds were sown without any pre-treatment on different dates and the results of germination are noted below.

TABLE II

Showing the period of germination of Atropa acuminata seeds sown in mid-summer

Date of sowing seeds	Date of germination	Period of germination in days	REMARKS
28–6–50	8–7–50	9	Germination fair in all the plots.
,,	14–7–50	15	
9–7–50	23–7–50	14	
10–7–50	20–7–50	10	
,,	24–7–50	14	
18–7–50	2–8–50	13	
19–7–50	4–8–50	15	
20–7–50	3–8–50	12	
22–7–50	6–8–50	13	
23–7–50	3–8–50	10	
,,	9–8–50	15	
25–7–50	9–8–50	13	

Discussion.—From the perusal of the Tables I and II it would appear that the *Atropa acuminata* seeds sown in March, i.e., early spring in Srinagar ordinarily take 4 to 5 weeks to germinate. The day temperature during these days varies between 50 to 70°F although the night temperature is much lower. This period of germination is shortened if the seeds are pre-treated with 80% sulphuric acid for a short time up to 2 minutes.

On the other hand it would also appear that these seeds germinated after ten to fifteen days when sown in the months of June and July, and without any treatment at Yarikah 7,000 ft. above sea-level. The day temperature during this period at Yarikah reached 80°F although the night temperature was low.

The germination of these seeds seems to be influenced by the time of sowing the seeds when the day temperature plays an important role. Mukerji and Dutta have reported that these seeds germinate in a period of 14 to 21 days when kept at a day temperature of 70°F although the night temperature might be somewhat low. Our experimental observations seem to confirm this.

Chemical treatment of seeds with sulphuric acid requires careful handling as it sometimes results in charring the seeds if the acid is not thoroughly washed away or the seeds are kept in contact with it for a longer period. It is expensive and not safe in the hands of peasants. Further work on the cultivation of Indian Belladonna is in progress.

The authors are indebted to Col. Sir R. N. Chopra for his valuable guidance.

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NON-CEREAL FOODS: TAMARIND SEED KERNELS AS FOOD AND FODDER

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In spite of the grow-more-food drive of the Government, the food situation in India is still far from satisfactory, and it may be many years before the country attains a stage of self-sufficiency. During the recent years the Government have been spending crores and crores of rupees in importing foodgrains from other countries. The problem may become more serious, if an armed conflict were to break out between India and Pakistan. It is, therefore, essential that not only more of normal foodgrains should be produced but also subsidiary food materials should be discovered to meet any emergency. During the search it is essential to see that (1) the starting material is in plenty, (2) it is easily collectable, (3) it is normally non-edible and is not utilized in any other way, and (4) its conversion into edible products should not involve much technique, labour or cost. Bearing these points in view and knowing fully well that the sages and *sadhus* have been deriving their entire sustenance from the forest products of this country since ancient times, several forest and other related products which are at present a waste or which are not being exploited to the full, have been examined in the chemical laboratory of this Institute. It has been found that among others tamarind seed kernels are such a material which is likely to offer a satisfactory subsidiary food.

Tamarind seed, which is a product of tamarind tree (*Tamarindus indica* Linn.) commonly found in peninsular India, is obtained as a by-product in the tamarind pulp industry. It has a thick brownish red outer coat (testa) and a creamy white inner kernel. The analysis of the latter is given somewhat differently by different workers,[1-5] the differences arising probably on account of seasonal, climatic and locality variations, but a typical composition is as follows :—

Moisture	10·2 per cent
Oil	6·4 ,, ,,
Albuminoids	15·4 ,, ,,
Tannins	1·6 ,, ,,
Crude fibre	2·0 ,, ,,
Free sugars	2·9 ,, ,,
Non-fibre carbohydrates, excluding free sugars	58·5 ,, ,,
Inorganic matter (by difference)	3·0 ,, ,,
Ash	2·5 per cent

A powder of this composition can be obtained by the following method :—The seeds, as separated from the tamarind pulp, are thoroughly washed with water in tubs in order to remove the attached pulp, if any. During this process, the hollow insect-damaged seeds float up, while the sound ones settle to the bottom. The sound seeds are separated from the spoiled ones, drained and thoroughly dried in the sun. If they were to be stored for any length of time, they should be kept in a dry place and fumigated with sulphur dioxide occasionally, particularly in wet weather, to avoid damage by insects. Otherwise, they are parched (avoiding any charring) for 30 minutes on hot sand at 145° to 150°C or in a hot-air chamber maintained at the same temperature. The parched seeds are then subjected to mild pounding with wooden mallets or passed through decorticators in order to remove the testa. The over-parched kernels, brownish in colour, if there are any, are picked out and removed. As an alternative to roasting for decortication, the seeds may be soaked in water for a day or so,

boiled for an hour, and the seed coat removed as in the blanching of almonds. The resulting creamy white kernels are washed in cold water, soaked for 3 to 4 hours in 0·5 per cent sulphur dioxide solution, washed again in flowing water and dried in the sun. The purpose of treatment with sulphur dioxide is to whiten the kernels ; if this were not required, the step may be omitted. The sun-dried kernels are further dried on a sand bath or in a hot chamber till their moisture content is reduced to about 5 per cent. Care should be taken to avoid any discoloration of the kernels during this operation. The dried kernels are then crushed and ground into powder of 80 to 100 mesh.

This powder, which is known as T.K.P. (Tamarind Kernel Powder), has been shown to be a good substitute for cereal starches for the sizing of cotton and jute textiles. At present, it is being employed in India for sizing to an extent of about 20,000 tons a year, thereby releasing 40,000 tons of foodgrains for human consumption, which would otherwise have been diverted for the production of the 20,000 tons of starch required for the textile industry. The amount of the T.K.P. used at present constitutes only 40 per cent of the total requirements of the industry, and this is due to some extent to the inherent pale yellowish tinge of the powder and to a great extent to the prejudice of the millowners against the use of T.K.P., and also to the vested interests of starch-manufacturing concerns. However, the colour as well as the performance of the powder can be very much improved by an admixture of cereal starches to an extent of 25 per cent. If T.K.P. or the processed product replaces all the starch required for sizing in the textile industry, it would mean a release of at least 75,000 tons of food grains for human consumption, and this is not a mean contribution at all in the present days of food scarcity. It is, therefore, incumbent on the Government and the industrialists alike to see that little or no cereal starches are used in the textile industry, since their place can very well be taken up by T.K.P. To achieve this end, some propaganda is necessary. Though the discovery of T.K.P. is nearly eight years old, the product is still comparatively new to the consumers and the latter are not taking to its use readily. Propaganda alone may not be sufficient ; along with it a certain amount of executive action on the part of the Government is also necessary, making it obligatory for the millowners to use T.K.P. as the size to an extent of not less than 75 per cent.

In addition to the indirect contribution of tamarind seed to the solution of the food problem, it can make a direct contribution also. The kernels are universally eaten by the poor in South and Central India during times of scarcity and famine ; they are also eaten by others in normal times. In Cochin, Travancore and the neighbouring regions, they are eaten like ground nuts. Even in North India, where tamarind tree is not grown to any appreciable extent, it is reported that some people mix the kernel flour with sugar and *ghee* and prepare *laddoos* for eating in winter. The *laddoos* are stated to be delicious and nutritious. It is also reported that a certain amount of the powder is finding its way into the composition of biscuits in some factories and also as an admixture with gram flour for the preparation of *bajjis*, *pakodis*, etc. (private information). The analysis of the kernel powder does not indicate the existence of any tonic principle in it, though it is stated that the powder, if not properly prepared (presence of husk) and used alone, may produce constipation and irritation. On the other hand, the seeds are regarded as medicinal. They are powdered and given for rheumatism in the Ayurvedic system of medicine and for herpes in the Unani system. They are also said to function as stomachic[1]. It is, therefore, suggested that the Government may get the kernels examined from the nutritional as well as toxicological points of view, so that, if there are no toxic effects, T.K.P. may be recommended for admixture with wheat flour in the preparation of *chapatis*, *rotis*, *halwa* and other eatables. If properly processed and manufactured it would constitute a very important subsidiary food, comparing favourably in food value with wheat and maize, as shown in the following table. For purposes of comparison the data for other cereals are also included in the table.

TABLE I.—*Analytical data of T.K.P.* and the common cereals*
(All data are given on moisture-free basis of the materials)

	Albuminoids %	Fat %	Carbohydrates %	Crude fibre %	Ash %
T.K.P.1,2,3,5	15·40–20·12	3·89–7·28	68·01–69·37	0·73–8·17	2·45–3·28
Wheat[6]	10·32–20·37	1·66–2·78	60·74–85·40	2·36–14·76	1·80–6·08
Rice[7]	6·12–10·48	0·22–0·83	84·19–96·00	0·22–0·48	0·45–0·71
Maize[6]	9·02–11·63	4·42–7·09	77·96–79·95	1·59–3·32	1·49–2·24
Barley[6]	8·34–12·96	1·58–2·74	77·21–78·35	4·28–5·55	2·50–3·20
Oats[6]	3·59–17·37	4·07–7·77	62·10–72·81	0·97–40·09	2·49–8·22

The use of T.K.P. as fodder has already been examined at the Veterinary Research Institute, Izatnagar. It has been shown that the amount of total carbohydrates and minerals present in the kernels compares favourably with those of oats and gram, while the crude protein is much higher than in barley, oats and maize (Table II)[5].

TABLE II

Name of the feed	Crude protein %	Ether extract %	Crude fibre %	Nitrogen free extract %	Total carbohydrate %	Total ash %	Calcium (CaO) %	Phosphorus (P_2O_5) %
T.K.P.	15·4	3·89	8·17	69·26	77·43	3·28	0·43	0·53
Barley	11·5	1·06	5·39	78·84	84·23	3·21	0·25	0·85
Oats	10·07	6·55	12·71	65·88	78·59	4·79	0·16	0·93
Maize	10·55	3·30	2·20	82·10	84·30	1·85	0·07	0·91
Gram	19·63	4·84	7·50	65·40	72·90	2·63	0·43	0·98

Feeding experiments on bullocks conducted over prolonged periods have shown that there are no adverse effects on the animals; on the other hand the cattle develop a fine bloom and put on weight. It is suggested that, keeping in view the practical feeding conditions, the kernels can go profitably into the fodder every day up to one-third of the quota.

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UTILIZATION OF OILS AND FATS FROM INDIAN FOREST SEEDS

BY S. V. PUNTAMBEKAR
Forest Research Institute, Dehra Dun

The world fatty oil supplies not being able to cope with the ever increasing demands for them for edible and industrial purposes, urgent need is felt not only to better utilize the present supplies of fats but also to find additional available sources for them. Thus the coconut oil group of fats, e.g., coconut oil, palm kernel oil, etc., which could be better utilized for edible purposes have to be, to a large extent, used in industry for soap making, hair oils, etc., on account of their certain desirable properties for the purpose. If suitable non-edible substitutes are found for them, as has been actually the case (Puntambekar, 1947, Indian Soap Journal, *3*, No. 6), these valuable and beneficial fats could be easily diverted for the much needed food purposes. The other important aspect of fatty oil utilization, to augment the present supplies, is their complete economic recovery from the oil cakes obtained as by-products from the oil-mill industry as well as from seed-kernels of low fatty oil content (between 10%–25%) by resorting to the solvent extraction process. This process is already widely practised in Europe and the U.S.A. but is practically non-existent in this country. At present it may be pointed out that almost all the oil-cake in this country is either used as cattle-feed or for manurial purposes and that all the forest seeds of the low oil content remain unexploited and actually go to waste.

2. The oils and fats from forest seeds that are used in trade at present are mahua (*Bassia spp.*) butter, dhupa (*Vateria indica* Linn.) fat, kokum (*Garcenia indica* Chois) fat, kusum (*Schleichera trijuga* Willd.) oil, nageshwar (*Mesua ferrea* Linn.) oil, pongamia (*Pongemia glabra* Vent) oil, neem (*Melia azadirachta* Linn.) oil, etc. They are to a large extent used for soap making and in a small measure for edible purposes, burning, ointments, etc. Except for mahua fat which is being largely used every where in soap making, all others are mostly produced and consumed locally.

3. There are a good many oils and fats of forest origin namely from the seeds of stillingia (*Sapium sebiferum* Roxb.), walnut (*Juglans regia* Linn.), bhang (*Cannabis sativa* Linn.), kamala (*Mallotus philippinensis* Muel. Arg.), etc., which are found to possess excellent drying properties but whose production for industrial purposes yet remains to be organized. Again there are fatty oils from other forest seeds namely those of *Bauhinia spp.*, *Prinsepia utilis* Royle, *Sterculia urens* Roxb., etc., which are edible but whose use for the purpose is rather local and remains to be extended. There are also fats of proved valuable properties and of considerable industrial demand like those from the seeds of *Lauraceæ spp.*, *Garcinia spp.*, *Dipterocarpaceæ spp.*, etc., which need systematic exploitation.

4. Commercial utilization of the fatty oils from the seeds of Indian forest plants is beset with several difficulties namely :—

(*a*) Irregularity in the annual fruiting of trees.

(*b*) Tediousness experienced in collection of seeds and the high collection costs, particularly when the trees are tall and non-gregarious.

(*c*) Ripening of seeds of many species near or at the beginning of monsoon and the consequent liability of fungus attack and deteriorations of the oil content on account of humidity.

(*d*) Uneconomic oil content (below 25%) of the seed kernels of a number of trees for expression purposes.

(*e*) Lack of cheap industrial solvents for extraction of the fatty oils from seed-kernels of low oil content.

It will be seen from the above factors that forest trees which are of medium size and of gregarious habit, which fruit regularly and seed profusely and which produce seed-kernels of oil content of over 25%, will only be suitable for exploitation of fatty oils from their seeds by the methods in use to-day. It is, therefore, no wonder that there are hardly half a dozen oils which at present constitute the commercial fatty oils from forest sources. The problem for this country is, therefore, how to utilize the majority of forest seeds which at present happen to go to waste. The following procedures have been recommended for the purpose :—

(1) Quantities of oil bearing forest seed-kernels (oil content above 10%) annually available should be determined by careful regional (forest division) surveys and the promising among them grouped together according to locality and ripening time. All the seeds from a compact area, ripening about the same time, should be collected and mixed together in a fixed proportion to yield a standard fatty oil, dried and expressed or solvent extracted for the oil contained in them and the oil thus obtained used for non-edible purposes, namely soap-making, lubrication, etc.

(2) Any particular oil bearing seed-kernels of oil content between 10–25% that are available in commercial quantities and that yield a valuable fat, viz., sal seed-kernels (fat content 16%), could be worked for the fat by a new process developed at the Forest Research Institute in which a suitable fatty oil has been used to extract the fats. The fats could be almost completely extracted from the seed-kernels with the oil and separated from it by cooling and filtration and the residual oil in the seed-cake recovered in a hydraulic press or an expeller. In this way the valuable edible sal fat useful for industrial applications could be obtained from an abundant forest product which is at present going to waste, the only loss being about 6 to 7% of the solvent oil in the cake, which also is recoverable by the usual solvent extraction.

THE EIGHTH ALL-INDIA SILVICULTURAL CONFERENCE

BY SHRI V. S. KRISHNASWAMY, I.F.S., *Secretary*
VIII Silvicultural Conference, Dehra Dun.

December 5th to December 14th, 1951

The VIII Silvicultural Conference—the first Conference to be held after the great political changes which have occurred in India—was held from the 5th to the 14th of December, 1951 at the Forest Research Institute. As a result of the new political set up, more Indian States were represented in the Conference. In addition, Shri C. H. Holmes represented Ceylon as a delegate, while Shri Aung Din represented Burma. Dr. R. O. Whyte, Shri C. Purkayastha and M. Marcel Leloup, Director of the Forestry Division of the FAO, represented the FAO at the Conference. Dr. H. G. Champion, Professor of Forestry, Oxford University, joined the Conference on 11th December. Dr. F. R. Bharucha, Professor of Botany, Bombay University, attended as an observer. The Central Water and Power Commission sent a representative, as also did the Timber Directorate of the Ministry of Commerce and Industry. On the whole 56 representatives took part in the deliberations, besides the officers of the Forest Research Institute.

As many as 125 papers were presented at the Conference. Abstracts of these papers had been sent to the delegates in advance so as to enable them to familiarize themselves with the subject matter of the topics discussed. This was a welcome improvement on the previous conferences of its kind. Another new feature was the issue of daily newsletters which briefly mentioned the day to day progress of the Conference, personnel of the conference committees appointed, and other information of use to the delegates and observers.

At the outset it became clear that the Board Room of the Forest Research Institute, where Silvicultural Conferences were held in the past, could not accommodate the large number of delegates expected. So it was decided to get the Convocation Hall ready for the purpose. This decision was taken rather late and thanks are due to Shri L. Simon and his colleagues for the personal interest they took in the matter. The semi-circular seating arrangement was ready in good time before the Conference and this arrangement evoked the praise of all the delegates.

On 10th December 1951, Dr. F. Yates, SC.D., F.R.S., Chief Statistician, Rothamstead Experimental Station, Mr. W. R. Leonard, Director, Statistical Office of the United Nations, and Professor M. H. Belz, who all had come to attend the International Statistical Conference at Delhi, attended the Silvicultural Conference. Dr. Yates addressed the members of the Conference on the "Role of Statistics in Forestry" and on the "Design of Forest experiments". Mr. Leonard spoke about the Statistical work done by the United Nations. Prof. Belz then followed with a short lecture on the importance of Statistics in general industrial practice.

On the afternoon of 11th December, 1951, the Conference members listened to a very interesting and instructive lecture on "Air Photography in Forestry" by Dr. Hart, Vice-Chancellor of Roorkee University, who attended the Conference as a representative of the Survey of India. His lecture, which was illustrated by numerous lantern slides, was heard with rapt attention by the members of the Conference. To those eminent statisticians and to Dr. Hart our grateful thanks go.

The proceedings of the Conference were inaugurated on 5th December with a welcome address by Shri C. R. Ranganathan, I.F.S., President, Forest Research Institute and Colleges. He said:

"Gentlemen,

"It is my pleasure and privilege to extend a most hearty welcome to the delegates to the VIII Silvicultural Conference. This Conference is one of the normal features of forest administration in this country and has been held at intervals for a very considerable period of time. The last conference was held in the year 1946 and we meet here to-day for the VIII Silvicultural Conference—the first Conference of its kind to be held in free India. This Conference has been regarded as an unusually important one by the various States. This will be evident from the fact that we have received over 100 papers as contributions to the Conference and we have here a very representative gathering of States in India and also our old friends who come from Burma and Ceylon. Nepal delegates who had come by mistake one month earlier went back to their State and I hope they will come back again, in time for this Conference. Burma and Ceylon are both independent countries, but for purposes of Silvicultural Conference they have been invited as delegates, because we were so closely associated with these States in the past. I cannot fail to mention the fact that the FAO is being represented at this Conference by Dr. Kollmann who has been here for about 5 months and by Dr. Whyte, who, I am afraid, has not yet arrived. We hope that Dr. Whyte will be here presently. I do not want to take more of your time and as you have a very heavy agenda before you, I will repeat my words of welcome and say how happy we are that you have been able to find time to come from long distances. I hope that you will be all comfortable and find the arrangements made here satisfactory. With your leave, gentlemen, I will now propose the Chairman for the day".

Shri G. S. Singh, I.F.S., Chief Conservator of Forests, Bombay, was elected as Chairman for the day.

After a brief introductory speech, Shri J. Banerji read out the address of the Inspector-General of Forests, Shri M. D. Chaturvedi which is as below :—

"Gentlemen,

"I deem it a great privilege indeed to have this opportunity to welcome you all to this VIII Silvicultural Conference which is being held under the ægis of the Forest Research Institute, Dehra Dun. My only regret is that my presence at Rome in connection with the Conference of the Food and Agriculture Organization of the United Nations has prevented me from being present in person at the opening of this Conference. I tried my best to avoid this clash by shifting the dates of our meetings, but unfortunately the Conference at Rome also did likewise. It will be my earnest endeavour to join you at the end of your deliberations.

"It occurs to me that this is the first Silvicultural Conference sponsored by free India. It is indeed gratifying to note that nearly all States of the Union are well represented. I am particularly beholden to the neighbouring States for taking part in this Conference. Forestry recognizes no political barriers and an integrated approach to the problems of this region augurs well of the future.

"I have been given to understand that you have a heavy agenda before you. Experience gained at previous Conferences in respect of the procedure and the form of resolutions to be adopted would stand you in good stead in conducting your business. I only wish to stress the need for modulating your proposals from the point of view of their implementation in actual practice. What is desirable must be subordinated to what is possible under the present circumstances.

"I earnestly hope that your deliberations would prove of inestimable value in the preservation and perpetuation of forests not only to the State you represent but to the region as a whole".

After this the following panel of chairmen was elected for conducting the day to day business :—

(1) Thakur Jhunna Singh, Chief Conservator of Forests, Punjab.
(2) Shri L. Rai, Chief Conservator of Forests, Madhya Pradesh.
(3) Shri G. S. Singh, Chief Conservator of Forests, Bombay.
(4) Shri N. P. Mohan, Chief Conservator of Forests, Himachal Pradesh.
(5) Shri S. Chowdhury, Conservator General of Forests, West Bengal.
(6) Shri N. D. Sahni, Conservator of Forests, Madras.
(7) Shri G. G. Takle, Chief Conservator of Forests, Vindhya Pradesh.
(8) Shri M. D. Chaturvedi, Inspector-General of Forests.
(9) Shri C. H. Holmes, Conservator of Forests, Ceylon.

A Resolutions Committee consisting of the following members was also elected :—

(1) Shri C. R. Ranganathan, President, Forest Research Institute and Colleges.
(2) Shri V. S. Krishnaswamy, Silviculturist, Forest Research Institute.
(3) Shri L. Rai, Chief Conservator of Forests, Madhya Pradesh.
(4) Shri G. S. Singh, Chief Conservator of Forests, Bombay.
(5) Shri S. K. Seth, Silviculturist, Uttar Pradesh.
(6) Shri N. P. Mohan, Chief Conservator of Forests, Himachal Pradesh.
(7) Shri J. Banerji, Deputy Inspector-General of Forests.
(8) Shri N. N. Sen, Conservator of Forests, Uttar Pradesh.
(9) Shri P. D. Stracey, Senior Conservator of Forests, Assam.

The Resolutions Committee was formed to give final shape to the resolutions drafted by the subjects committees.

The Central Silviculturist was elected to be the Secretary of this Conference, besides being *ex officio* Secretary for the different subjects committees.

M. Marcel Leloup, Director of Forestry Division of the Food and Agriculture Organization of the United Nations, along with Shri M. D. Chaturvedi, I.F.S., Inspector-General of Forests, came straight to Dehra Dun from the FAO Conference held at Rome, on the evening of 11th December.

After the transaction of this preliminary business, the regular work of the Conference began. At each session of the Conference various subjects, as shown in the agenda, were discussed and a subjects committee was formed for each item, for drafting resolutions for the consideration of the Conference. These resolutions were scrutinized by the Resolutions Committee and presented to the Conference, which finally adopted all of them with some minor alterations. These resolutions will be published in the next issue of the *Indian Forester* as they will be of considerable interest to the readers of this Journal.

On 6th December Dr. F. R. Bharucha read a paper on "Vegetation Cartography". This paper will be published in an early issue of the *Indian Forester* with a view to eliciting the opinion of forest officers on the methods of cartography proposed.

A group photo was taken of all the Conference members on the morning of 11th inst. at 9 a.m.

Conference members went on excursions to Dehra Dun and Saharanpur forest divisions, on 8th December 1951.

The following documentary and other films were shown to the members of the Conference on 6th and 13th December :—

Documentary films :

(1) Green glory.
(2) A heritage we guard.
(3) Birth of the soil.
(4) Life of plants.
(5) Trees to tame the wind.
(6) Treasures of the forests.

Other films :

(1) F.R.I. Sports and Convocation, 1949.
(2) A.I.C.C. Session at F.R.I.
(3) Valley of Kashmir.
(4) Botanical Garden at F.R.I.
(5) Some beautiful flowers of New Forest.

On Sunday, 9th December, the members of the Subjects Committee on "Topsyturvy Thinnings" were taken to the Demonstration Area where a practical demonstration of the new concept of thinning was given by its author, Shri Pratap Singh.

On the afternoon of 12th December, after attending the ceremony of turning the first sod in the foundations of the new building for the Cellulose and Paper Branch, members of the Conference were taken round the Research garden and Demonstration area by the Central Silviculturist.

On 14th December 1951—the final day—Shri M. D. Chaturvedi, I.F.S., Inspector-General of Forests, presided over the deliberations. M. Marcel Leloup addressed the Conference on "The Place of Research in National Forest Policies" as follows :—

"The member governments of the FAO, at the sixth session of their Conference recently concluded at Rome, unanimously adopted a resolution which, if faithfully observed by these same governments, may well prove to be of historic significance in world forestry.

"I can certainly say that the Government of India and its forest authorities, through the persistent support given to this resolution—particularly at the FAO Conference itself-contributed in no small measure to the successful crowning of our efforts.

"The object of this resolution is to set an end to the abuses which, still to-day, cause every year the senseless and often irreplaceable loss of one of the most essential natural resources of the world. Its object is to conserve the forest domain for mankind, not indeed for the mere sake of conservation, but to the end that present and future generations may derive in perpetuity, all the benefits that forests can provide.

" One of the sections of this important declaration reads as follows :

" Adequate knowledge of all aspects of forest resources, forestry, and the consumption and utilization of forest products, is indispensable. This includes, in varying degrees at the different stages of development of forest policy, a knowledge of the resources available on

forested lands or of those that should be made available on idle lands of the national needs for forest products : of the natural laws that apply to forests : and of the techniques employed in the production of forest crops and the utilization of their products. To this end, research should be organized and expanded to keep pace with all developments in the fields concerned, and the applications of the results obtained should be consistently encouraged".

* * * * * * * *

"The importance attached to forest research, in the widest sense of that term, in the resolution to which I have referred, is easy to justify.

"Forest Research has two essential objects. It is no exaggeration to say that, without systematic research, no national forest policy can be either properly formulated or be implemented. In other words, research is fundamental to the formulation of a forest policy, and alone can ensure and facilitate its execution.

"A national forest policy must be built upon the general basic principles set forth in the resolution of the FAO Conference. It must, however, be elaborated in the light of the physical, social and economic conditions prevailing in each country : otherwise it remains merely a recitation of principles without practical import. These physical, social and economic conditions must be ascertained and their effects on forest development and on forest industries must be analysed. Here is an enormous field of activity for research.

"The physical conditions of a country change little with the years but the effects of various natural factors on the life of the forest are very complex and interwoven. Knowledge of these effects can only be gained slowly and may need several decades.

"Social and economic trends at a given time can certainly be determined more easily, even though, in the case of great countries, it may require fairly complicated techniques. But trends change and continual attention is needed, if forest policy is to keep up with reality.

"The field which forest research must concern itself is thus so wide that the task, for any country first attempting to formulate a sound forest policy, may appear impossible. Many countries, and not the least your own, have proved that this is not true.

"It must be admitted, of course, that there are various stages to the development of forest policy and that forest research can only be developed by corresponding steps. But the process can be accelerated by co-operation between countries, particularly between countries of the same region, and that is why FAO appreciates so highly the generous offer made by the Government of India to organize here, at this very place, a regional centre for forest and forest products research.

"The role of research is not, however, limited to providing the data on which the authorities responsible can draw up the framework of national policy or elaborate its details.

"Let me quote a simple example. Supposing that a thorough examination has shown that the afforestation of lands not used for agriculture is physically possible, economically advantageous and socially desirable, whereupon the authorities concerned have decided to give their forest policy a bias in this direction. Research must again be brought to bear on the problem.

"On the economic and social plans, research must indicate where afforestation would be most beneficial and determine the needs that should be given priority consideration.

"On the physical level, it must answer the question as to which species can best and most quickly serve the object in view.

"It must show the way to the best nursery and planting techniques, and to the most suitable treatment to be given to the plantations ; it must indicate the best protection against natural enemies and hazards, and reveal the effects on soil and its future productivity.

"And let me say at this point, a co-ordination of research in the three different spheres continues to be essential.

"There are two other points regarding forest research to which I want to draw your attention. These considerations are inherent in the passage from the resolution which I quoted to you just now; but they seem to me to be so important, especially for tropical countries, that I cannot pass over them in silence.

"The first is that research, equally on forestry and forest products, should be co-ordinated by a single authority. I am happy to know that in your country this is plainly recognized, and that an appropriate organization to this end exists. There are obvious difficulties in this respect, especially since forest research should be as decentralized as possible, whilst forest products research, simply because of the expense involved, is best concentrated.

"I said that these points were especially important in the case of tropical countries. Is it not true that the most serious difficulties confronting such countries in trying to practise sound silviculture lie in the complex composition of the forests and the impossibility—at least until recently—of finding suitable uses for much of the raw material that the forests provide? Before we come to the many interdependent problems attendant on any intensive management, the utilization of these forests, surely their development depends basically either on securing greater uniformity in the growing stock and an increase in the proportion of species of high commercial value, or on utilizing the greatest possible number of species, or on a combination of both alternatives.

"The first course necessarily requires intensive silvicultural research; the second involves forest products research. Both kinds of research must be undertaken together because from the point of view of systematic research programmes, what is learned from silvicultural research may have a distinct bearing on utilization research, and the reverse is also true.

"For tropical countries, as for other countries, the link between forest research and forest products research must be of the same order as the association between the forest itself and the industries dependent on the forest.

"The words 'research programmes' which I have just used bring me finally to my second and most important point. The term 'programmes' itself implies a degree of orientation—greater emphasis given to certain lines of investigation than to others, and a continuity in pursuing certain objectives. One can almost say that there is, or should be, a 'research policy' within, and closely linked to, 'forest policy'.

"This idea is often misunderstood and those who advocate it are often accused of wishing to put science into a strait-jacket.

"We may concede that research for its own sake sometimes yields results of great practical importance, which sometimes is appreciated only long afterwards. Such instances are often more spectacular than convincing and we may wonder whether in actual fact pure science does not develop with the development of man and is given its direction by the unconscious needs of mankind.

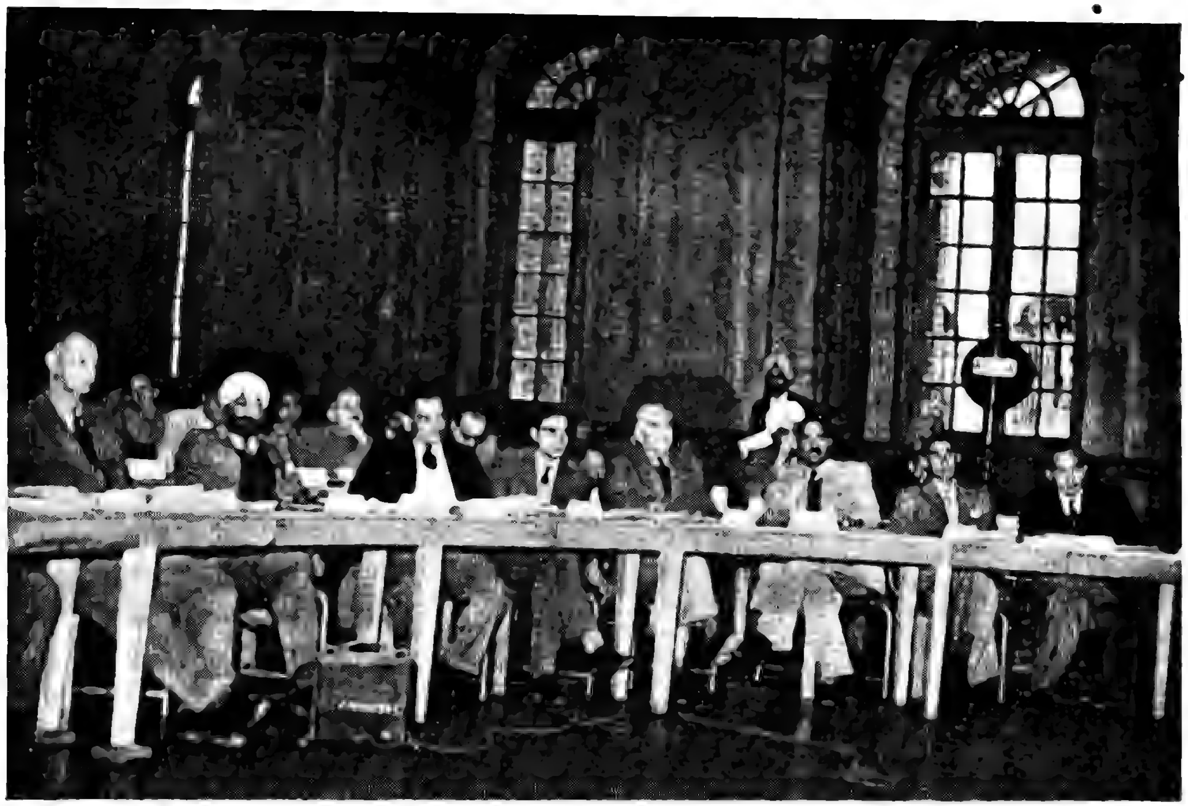
"But I am not here concerned with pure science. Forestry sciences are applied sciences as their very name implies. No doubt experts in forest and in forest products research must keep abreast with developments in the pure sciences, which are the very basis of their own research; and the practical application of any finding of pure science can obviously be profitably investigated if they seem to serve the aims of the national forest policy adapted to the peculiar needs of the country. It is precisely along these lines that any policy of forest research must be directed.

FOREIGN VISITORS

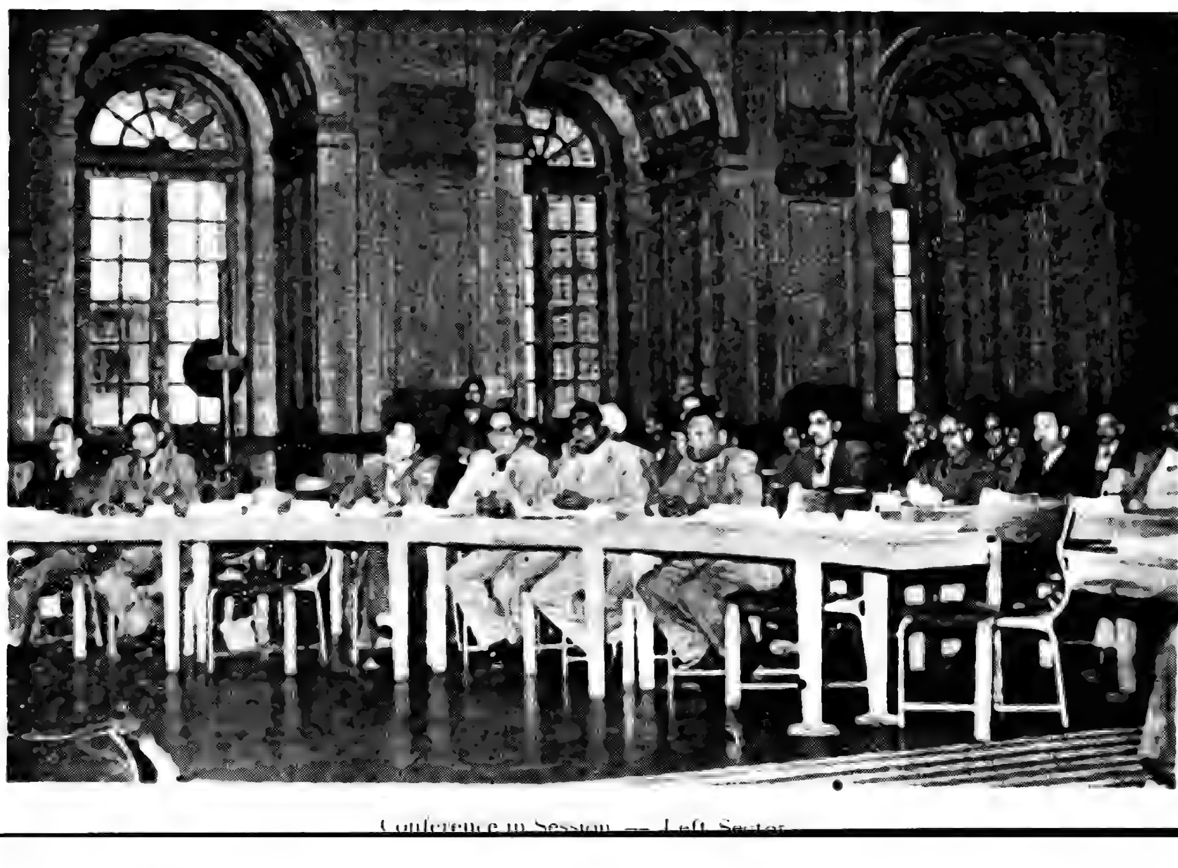
Messrs. V. S. Krishnaswamy; C. R. Ranganathan; Prof. H. G. Champion; Dr. R. O. Whyte; Mr. W. R. Leonard; Dr. F. Yates, and Prof. M. H. Belz.

CONFERENCE OFFICERS

Messrs. V. S. Krishnaswamy (*Secretary*); M. D. Chaturvedi (*Chairman*); C. R. Ranganathan (President [illegible] (Director of Forestry Division, F.A.O.).



Conference in Session — Right Sector.



Conference in Session — Left Sector.

"I do not mean by what I have just said that the authorities responsible for forest policy must dictate how forest research should be conducted. For instance, in countries lucky enough to have them, independent forest research institutes play an invaluable part. They are well placed to co-operate with research in the pure sciences, and also help towards that decentralization which I have already said is most important, at least in the case of silvicultural research. However, despite this, it is the duty of those responsible for forest policy to give the initial impulse to research, to secure its co-ordination, and the wide dissemination of results.

"Research, gentlemen, in the field which interests us, has a most tremendous importance. It belongs, it is true, to institutes and laboratories. But each forester, each timber expert, must also be a research man, or at least a meticulous observer—and systematic observation is the essence of research.

"Nevertheless, I am firmly convinced that research, to which all of us should contribute, is sterile if it is not given a sensible purpose. That is why I want to ask you always to pay heed to the substance of the principles that I quoted to you. It will be by giving them due regard that your activities will be really useful to your country, to this whole part of the world where your country has such an important part to play, and so ultimately to the world at large".

Then the resolutions of the Conference were put to vote and passed unanimously. The IX Silvicultural Conference was proposed to be held towards the end of October 1956. The Inspector-General of Forests delivered the following closing address :

"Gentlemen,

"Our labours have come to a close. I must confess that the deliberations of this Conference have given me very great satisfaction and a certain measure of pride. As a matter of fact, when I was listening to the discussions that have been going on during the last few days, I was cursing myself that I had not been here to listen to the discussions from the very beginning. As a matter of fact, the discussions that went on in my presence have convinced me of their quality, depth and effectiveness. It is not sufficiently recognized that in a conference of this nature, it is absolutely essential that there must be differences of opinion because it is from the impact of conflicting views that we thrash out the husk and produce the corn. The position as I see to-day, and as has been pointed out by Mr. Hopkins, is that you have painted on a very large canvas. The recommendations and the resolutions leave no doubt that you have certainly set yourselves a difficult task. When you return to your States, you must try your best to use your good offices to influence your Government, to get these resolutions implemented. The implementation of these resolutions is always a difficult matter, as Mr. Hopkins has said. But there is something to be said to the heads of the forest departments. It was rather distasteful when I heard heads of departments always blaming their Governments for their inability to carry out these recommendations. There is much consciousness of forestry—very much more than ever before. The policy of *laissez faire* adopted by the former administration is a thing of the past. I have noticed that the ministers of popular governments are very much awakened to a sense of their responsibilities in the matter of administration of forests.

"As a Chief Conservator of Forests and as Inspector-General of Forests, I have had the most excruciating experience of my most considered plans being turned down by Government, but that should not discourage us. I have discovered to my own cost that it has been due to my own fault. That failure should be utilized to stir up our imagination and enable us again to present the thing to the Government. And I am one of those persons who have won in the long run. What is required is a certain amount of persistence in your efforts. You must go to your minister again and again and explain to him your point of view.

"As I go round the country, touring in the various States, I must confess that I am very much struck by the all-round development which is being made in the general administration of our forests. I can cite, for example, the work that is being done in the development schemes of Bombay State ; various plantation schemes in Madras ; and, if you remember, various other schemes in respect of private forests. I do not know whether I should mention it. But, whenever a new scheme is put through and whenever I meet with a failure I always remember the orders of a Governor who wanted the afforestation scheme to be closed down as being of no consequence. It was written by one of the distinguished British Governors that the afforestation division in U.P. should be closed down. Had this been said by any of the present Congress Ministers, people would have laughed at the suggestion, but because he was a British Governor, nobody raised his finger. At present in U.P. where previously there was only one afforestation division, we have now four. There is also a land management circle. The progress we have made in the direction of forest management, in the direction of control of private forests, during the last few years, is very encouraging. In the Forest Research Institute itself, you must have noticed modern equipment in the various laboratories and also watched the ceremony of turning the first sod in the foundation of the new paper plant buildings, where the blessings of the Gods were invoked. I was all the time thinking of invoking the Gods of finance to get the money.

"Going round the continent, meeting foreigners, I have been surprised at the persistent campaign of lies conducted abroad in the foreign press to the effect that ever since the British left India, we are squandering away our forest resources. The thing is all the more serious, because it is being done in a certain manner in which I have no opportunity of breaking this web of lies. Mr. Champion, who is the Professor of Forestry in Oxford, has attended this Conference—the first conference in Independent India. He has gone round the Institute and will also be going round some of our State forests. The influence he exercises carries great weight. I would beg him to use his good offices to give the lie direct to this campaign that is going on against our country. I am very grateful to Mr. Champion for all the trouble he has taken to attend this Conference and give us his valuable advice.

"My thanks are also due to M. Leloup, who has travelled all the way from Rome to attend this Conference. It is due to his genius that we had Forestry in the FAO. ' Forestry has no place in the FAO' said a certain gentlemen at the FAO, whom I do not want to name. He went to the extent of saying that 'we do not eat wood'. It is not sufficiently realized that people burn their farm-yard manure in India and food is not available in this country. We have, therefore, the grow-more-food campaign, adding to it, the grow-more-wood to grow-more-food slogan. That is the way you can divert the farm-yard manure from the villages to the fields.

"I will be failing in my duty if I did not express my thanks to Mr. Ranganathan, the President of the Forest Research Institute and Colleges, whose technical ability is only excelled by his organizing capacity. It is due to the hard work that he has put in, in organizing this Conference that it has achieved success. I think you will agree with me that I must say my thanks for the unstinted hospitality of the officers who are working here at this Institute for entertaining the delegates from the various States. People who come here to attend such Conferences, do not recognize the fact that these conferences are becoming a frequent affair and our poor officers have to entertain them—and entertain them in the right way ! I feel I am voicing the feelings of the delegates that they are very grateful to them for their hospitality. That is not all. I wish to tell you that the value of such conferences, quite apart from the social functions like cocktail parties, tea parties and dinners they provide, lies in the fact that people become acquainted with one another. There is nothing more conducive to social contact than these social functions. Social contact is brought about by social functions.

As for myself, I came to know the Silviculturist from West Bengal and the young Silviculturist for Assam. Before this I only knew them by their names.

"Well, gentlemen, my task is completed. I have a feeling that you all will go away with very pleasant memories of this Conference. I will be going away for good and will not, therefore, be present at the next Silvicultural Conference. I feel you will lend a helping hand in order to get these resolutions implemented. I must sincerely thank everybody here for the pleasant atmosphere in which the discussions were held. As I have mentioned, in order to avail of the advantage of difference of opinion, if you import heat into the discussions, it should not permit the atmosphere to be vitiated. I was so happy to see that although opinions were readily opposed, everybody was laughing. Unless you have this congenial atmosphere, of cheerful discussions, we will miss the bus completely. I must, therefore, thank you for the way in which you have conducted these discussions.

"Thank you very much".

Thereupon Shri C. R. Ranganathan, President Forest Fesearch Institute and Colleges, proposed a vote of thanks in the following words :

"Mr. Chairman, Ladies and Gentlemen,

"As this Conference draws to its destined close, I may confess a feeling of deep satisfaction over the manner in which it has proceeded from day to day. I must also confess a certain amount of lightening of the heart and slackening of the strain. As you can well imagine, a large conference of this nature, extending over 10 days, is not a very easy thing to run smoothly without acrimony or some kind of breakdown. I think we may fairly claim that nothing of that kind has happened and that things have gone reasonably well, and I hope that the delegates who have attended this Conference are not dissatisfied with the arrangements made both for their accommodation and the Conference meetings.

"As you may have noticed, the scope of this Conference has, by an imperceptible process, become enlarged as compared with the previous conferences. Whether it is a good thing or not, I do not know, but certainly we have taken into consideration during this conference matters which were not touched upon at all in the previous conferences. For example, to-day we discussed and passed a resolution relating to the collection of Statistics ; we have paid some attention to the statistics relating to forest products. We have also discussed *in extenso* matters relating to forest policy. We have, in a sense, covered a very wide field in forestry although we have kept utilization methods out of the purview of our discussions.

"As a reflection of the large scope of this Conference, we have received a record number of contributions for it. I understand from the Silviculturist that the number is 125. I do not know whether the latest contributions have been incorporated or not. However, I hope, gentlemen, you will agree that the output of literature is fairly large.

"It is now my pleasant duty to thank the various delegates who have come from various states at much inconvenience to attend this Conference and in particular to thank those delegates who have contributed valuable papers and contributed to the discussions during the Conference session. I have attended the World Forestry Congress at Helsinki and I may say without fear of contradiction from my friends Professor Champion and M. Leloup that the standard of debate at this Conference was, if not superior, in no way inferior to the standard of debate at the World Forestry Congress.

"We are also very grateful to the representatives of other Government departments, namely, the Central Water Power Commission and the Ministry of Commerce and Industry, for attending this Conference. Their contributions to the discussions have been very valuable indeed, in particular, the contributions made by the representatives of the Ministry of Commerce

and Industry, because he is no stranger to this Institute. Naturally, the vast experience he had behind him was of very great value during these discussions.

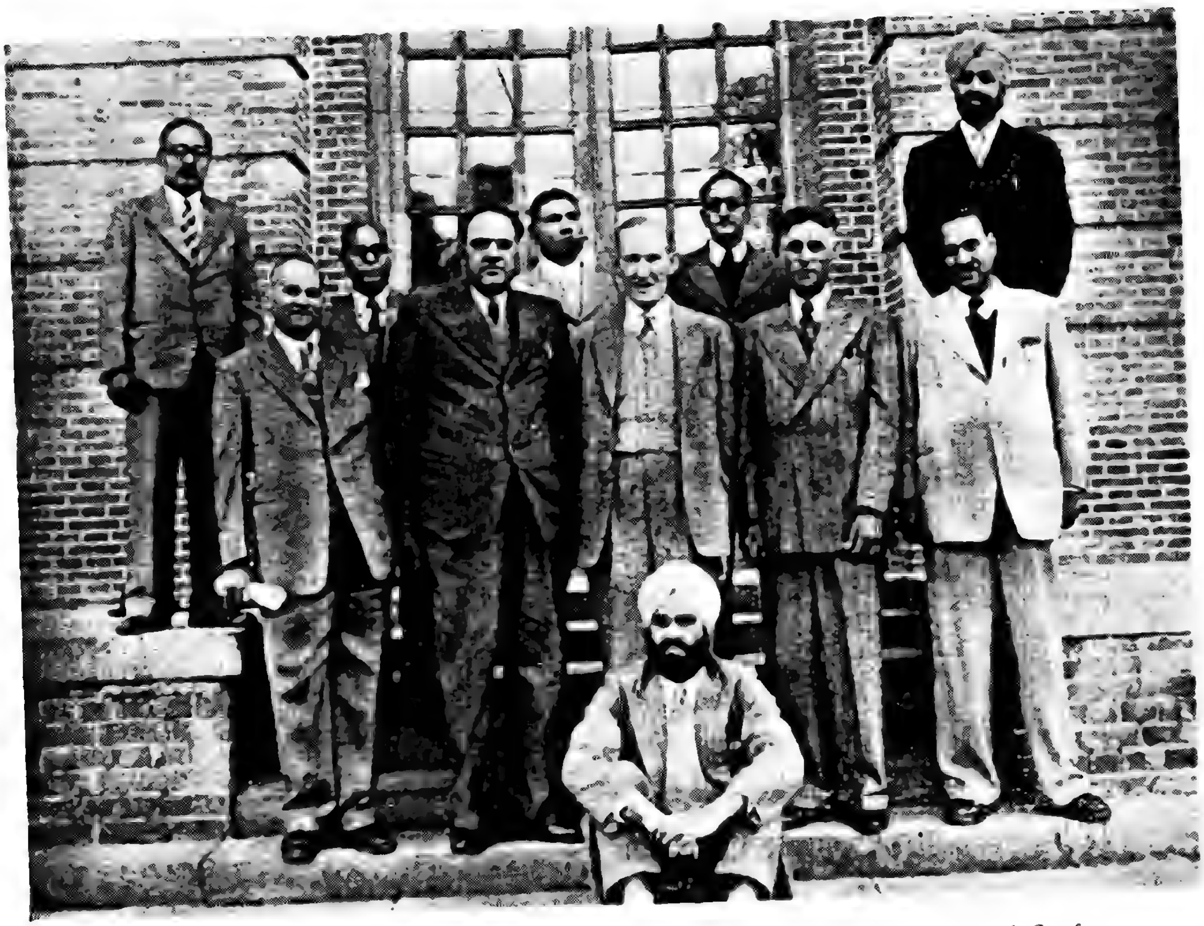
"Another feature in which this Conference differs from all previous conferences is the fact that for the first time we have the representatives of an International Organization—in fact several representatives of the Food and Agriculture Organization—present here in this Conference. And it is my pleasure to thank them very much indeed for having taken this trouble to come here from so far away and particularly for taking part in the discussions. In particular, it gives me great pleasure to extend a warm welcome to my old friend, M. Leloup. This is the second time that he has paid a visit to this Institute and he is always welcome. Prof. Champion of Oxford is a great friend of ours. He is no stranger to us. It is a happy coincidence that his visit to India coincided with this Conference. He has slightly altered his dates in order to be able to be present at this Conference and we are very grateful indeed for his presence here and also for the very valuable contributions he has made to it.

"Of our Inspector-General of Forests, I need not say much. It was regrettable—and in many ways a sore disappointment to many delegates here—that he was not here at the opening of the Conference. I did my best to fill his place. I can assure you that I tried hard to persuade him to cut short his stay at Rome and come here, but possibly the pressure of his duties there, or perhaps other alternative attractions, prevented him from coming back in time. You may rest assured that he was so keen on attending this Conference that he wrote to me that we should extend the Conference by a few days in order to enable him to attend. But, in view of your long stay here, I am afraid, that was not possible. Consequently, he had to hurry back to get here in time. We are grateful to him for coming to this Conference and for all the guidance he has given to its proceedings. We are indeed grateful to him for his valuable contributions to the debates in this hall as well as in the conduct of the Conference.

"Coming nearer home, it is my pleasant duty to thank the staff of the Silviculture Branch. This Branch has been at work preparing for the conference for nearly a year and I can tell you from my own knowledge of the work done in the Silviculture Branch, that it has not been a light burden, as Mr. Champion knows very well. I may tell you that we have employed no additional or temporary staff of any character for this work. The normal staff of the Silviculture Branch has carried this tremendous burden and acquitted itself very creditably.

"When I discovered that this Conference was going to be of rather larger size than was contemplated, it became obvious that it could not be held in the Board Room where previous conferences had been held. Unfortunately, this was discovered rather late, some time during the last week of last month. I, therefore, called upon my wood workshops to provide these tables and I said the job had got to be done in a week's time. It was done within a week's time and I hope you will agree with me that it has been done in a very satisfactory manner.

"It is always invidious to single out a name for special mention but I think I should be failing in my duty, and I am sure you will agree with me, if I did not mention the name of Mr. V. S. Krishnaswamy, the Central Silviculturist. He has put in very hard work in the preliminary organization of this Conference and in the conduct of its proceedings from day to day. One of the new features introduced during this Conference is the daily bulletin summarizing the previous day's proceedings, accompanied by caricatures drawn by an officer of the Institute. That has tended to improve the atmosphere of the Conference besides supplying valuable information to the delegates. Mr. Krishnaswamy joined this Institute in February this year and being a new man to this sort of work, he has had to work extra hours. As the papers started coming in a few months ago, he had to work long hours to get them duplicated and, in many cases, he had to prepare the abstracts himself. You can imagine what an amount



Officers of the Silviculture Branch past and present who attended the Silvicultural Conference.

Standing
1st row—S. Venkateswaran (Travancore), Jagdamba Prasad (Delhi), Mahendra Prakash (Rajasthan), V. P. Mathur (F.R.I.).
2nd row—R. C. Kaushik (F.R.I.), M. L. Saikia (Assam), F. R. Bharucha (Bombay), U Aung Din (Burma), Khem Chand Malhotra (Punjab), R. S. Gupta (F.R.I.), B. Das (Orissa), M. P. Das (Orissa), K. N. Raghavan Nair (Madras), K. P. Sagreiya (Nagpur), D. D. Saigal (Delhi), A. Banerji (F.R.I.), N. D. Sahni (Madras), G. S. Mathauda (F.R.I.), R. B. Majumdar (Madhya Pradesh), P. W. Augier (Bihar), K. Kadambi (F.R.I.), R. R. Chowdhuri (Bombay), R. L. Khajuria (Kashmir).
3rd row—S. K. Seth (Uttar Pradesh), P. N. Kaul (Kashmir), D. Banijbhatana (Thailand), M. Shariffuddin (Hyderabad), P. D. Stracey (Assam), Ram Sinhji Rathod (Cutch), Bakshi Sant Ram (Himachal Pradesh), J. Banerji (Dy. I.G.F.), R. D. Rai (Hyderabad), Balwant Singh (P.E.P.S.U.), D. H. Kulkarni (Madhya Pradesh), G. S. Puri (F.R.I.), I. M. Qureshi (Bombay), J. N. Sinha (Bihar), C. H. Holmes (Ceylon), J. N. Sen Gupta (Bengal), D. A. Rama Rao (Mysore), S. Mahaphol (Thailand).

Seated—G. M. Hopkins (Uttar Pradesh), P. N. Deogun (Saurashtra), N. N. Sen (Uttar Pradesh), G. G. Takle (Vindhya Pradesh), N. P. Mohan (Himachal Pradesh), R. O. Whyte (FAO), M. Leloup (FAO), V. S. Krishnaswamy (F.R.I.), M. D. Chaturvedi (I.G.F.), C. R. Ranganathan (President, F.R.I. & Colleges), H. G. Champion (Oxford), C. Purkayastha (FAO), L. Rai (Madhya Pradesh), S. Chowdhury (Bengal), G. S. Singh (Bombay), K. L. Aggarwal (F.R.I.), Pratap Singh (Punjab).

of labour he had to put in, in this job and you may have noticed that from the size of the volume of abstracts. I think it is only right, therefore, that we should show our appreciation of the great work that Mr. Krishnaswamy has done.

"While extending my gratitude to delegates, I forgot to single out for special mention—as I ought to have done—the delegate from Burma and the delegate from Ceylon. This omission, you will agree, is very natural, as we do not regard these gentlemen as foreign delegates at all. They have always been associated with the previous conferences and although they belong to foreign countries, we do not regard them as foreign delegates but treat them in exactly the same way as we treat our delegates from Bombay or Assam. I thank them very warmly for their co-operation at this Conference.

"Finally, one word about our stenographers. For the third occasion we were promised parliamentary reporters and at the last moment, we were told that they were not available. But this did not surprise or dismay us. I said, never mind, we will carry on with our own resources supplemented by the stenographers of the I.G.F. and the Dy. I.G.F. In a very real sense, they have borne the heat and burden of the debates here, and have had to work late hours in the evening. More particularly, they have laboured long hours yesterday and this morning in producing copies of the resolutions which were only shaped last night and this morning. I think a special vote of thanks is due to the stenographers of the Forest Research Institute for the work they have done".

Shri J. N. Sen Gupta made a suitable reply.

Then after the presentation of souvenirs by the Inspector-General of Forests to Mr. Leloup, Professor Champion, Dr. Whyte, Shri Purkayastha and to all the Conference members, the Conference was declared closed, amidst loud cheers.

The occasion was not merely one of debates, discussions and committee meetings. The social side was by no means neglected. The well known hospitality of the officers of the Forest Research Institute and Colleges found full play. The private parties organized by individual officers in honour of groups of members were too numerous to be listed here. Mention should, however, be made of three general parties to which the whole Conference was invited. The first of these was a cocktail party given by Mr. and Mrs. C. R. Ranganathan at their residence on 7th December 1951. This was followed by a tea party given by Mr. and Mrs. V. S. Krishnaswamy at 16 New Forest, on 10th December 1951. On 11th December, the President and Officers of Forest Research Institute and Colleges were at home to the members of the Conference and their wives, the party being held on the beautiful terrace north of the Forest Research Institute main building, the band of the National Defence Academy being on attendance. Our thanks are due to the Commandant of the National Defence Academy for this courtesy.

Besides this, we understand that many of the members of the Conference who were housed in the Indian Forest College hostel and who had joined the Mess, had a good time and continued the deliberations of the Conference till late in the night, amidst congenial surroundings, without the surveillance of a Chairman !

In short, we understand that the Conference has left very pleasant memories both for those who organized it and for those who took part in it.

We are grateful to those who spared no pains to make this Conference a success.

(All the Conference photos were taken by Shri V. K. Sharma—Head Photographer of the Silvicultural Branch, Forest Research Institute).

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THE FORESTS OF TRIPURA

BY S. K. DATTA

Conservator of Forests, Tripura

SITUATION

The unclassed forests and the reserved forests together cover about three quarters of the total area of the State which is roughly 4,000 square miles in extent. The forests are distributed all over the tract in blocks of varying sizes mixed with cultivated fields. It is, therefore, necessary to give a description of the terrain as a whole.

Tripura is a hilly country situated in the north-east of India, not far from the Bay of Bengal. It is bounded on the north and west by the plains districts of E. Pakistan and on the south and east by the hills of Assam and of the Pakistan. It is entirely made up of parallel hill ranges running north and south and alternating with narrow valleys. The ranges of hills rise from the plains of Sylhet in E. Pakistan to the north and proceed southwards until they join the hills of the Chittagong Hill Tracts which are also in E. Pakistan. The easternmost range adjoins the Lushai hills of Assam. The elevation of the hills gradually increases in the south, and each range as a whole is higher than the other to its west ; that is to say, the easternmost range, called Jampui, is the loftiest being 3,000 feet high and the westernmost called Barmura—Deotamura the lowest, its elevation being 800 feet.

The hills rise abruptly as a rule and the slope eases gradually near the top which is usually nearly flat. Low hills detached from the main ranges occur in the north and west and in the valleys in the interior. The valleys, which are not very broad, are in general slightly undulating or flat. The main direction of drainage is from south to north. Each valley contains a stream to which smaller hill streams join carrying water from the hill-sides and following all sorts of directions. The big streams ultimately flow into the rivers of E. Pakistan. The western and outermost hill range (Barmura-Deotamura range) is drained by Howra, Gumti and Muhuri which follow a westerly course. Some hollows of considerable size exist, which are enclosed by hills causing swamps and Beels.

GEOLOGY AND ROCKS

The following description of rocks is largely collected from notes of the former State Geologists.

The rocks constituting the country are mainly of 3 kinds. They lie one over the other in the order given below but are unconformable with one another, the unconformities being marked by uneven surface and conglomeratic beds. They are found buckled and folded in places. All these rocks belong to the tertiary age.

The lowest rock consists principally of yellow to pink, fairly hard and fine grained sandstones. Some calcareous fossiliferous bands of coarse sandstone, blue-grey slates and shales also occur in it. They are related to the Barail (Anversian–Chattian) series of Assam. They form the axes of the eastern ranges of hills, such as, Jampui, Unakoti and Sakhan.

The middle group of rocks consists of medium to coarse grained bluish, massive sandstones and some blue-grey shales, but they are softer than the foregoing type. Stringers of coal and calcareous sandstones are found. The rocks may be correlated with the Surma (Chattian–Burdigalian) series. The sides of the eastern hill ranges and some of the entire

hills of the western ranges are composed of these rocks. The old engravings seen in the area are cut in these rocks.

The upper rocks are soft, coarse yellow sandstones and soft, dirty white or grey shales. They abound in fossil wood. This is fossil wood group similar to the Tepak (Burdigalian–Vindabanian) series of Assam. The western low hills and the sides of the Baramura–Deotamura hill ranges are largely composed of them but they are not distinguishable everywhere in the eastern ranges.

The isolated hills and high land are often made up of layers of sand and gravel greatly indurated with ferrugineous cement clay.

Deposits of laterite and ferrugineous concretions (morum) are found at some places at the top of the rocks of different groups in all the hill ranges but more prominently in the western hills near Agartala, from Simna to Melaghar and near Belonia.

The flat land is alluvium being composed of clay and sand in varying proportions.

SOIL

The soils resulting from the above rocks are lateritic, or grey to brown sticky clay which becomes hard in dry weather, or sandy loam to loamy sand. The soils are fertile except the lateritic soil.

CLIMATE

The climate is moist and warm in general ; timely rain checks the rise in temperature. It is not unhealthful in the hills but malaria is the bane of life in the valleys. The climate in the tallest hill range, the Jampui hills, is pleasant and salubrious. The average annual rainfall recorded at the headquarters town of Agartala is about 80 inches and the temperature varies between a maximum of 99 F and minimum of 49°F. Hail storms do some damage to field crops sometimes, but the violence of storms is usually not so great as to cause great damage to the forest crop. There is scarcity of water in the hilly region, specially in the hot months of March and April. People draw water from cheras (small streams) or springs, if there be any, at the bottom of hills. Occasionally flood occurs submerging the town of Agartala .It causes inconvenience to towns-people but heavy damage to crop within the State on account of flood is seldom reported.

AREA, SURVEY, DISTRIBUTION, LEGAL POSITION, RIGHTS AND CONCESSIONS

The area of reserved forests is approximately 1010 sq. miles and that of Khas forests another 2,000 sq. miles out of a total of 4,000 sq. miles of the area of the State of Tripura. The Khas forests are distributed all over the country. Some of them, specially those close to the boundary, are scrub-jungle or bare land. Reserved forests are constituted in 29 blocks, some are contiguous to one another. Most of them are far removed from the State boundary but some valuable forests are on the border land, tempting small thefts and large scale raids from Pakistan, beyond the border. One of the forests (Tulakona), not formally declared as reserved forest and, therefore, weakly controlled, is close to the town of Agartala ; it is of great economic importance to the towns-people for fuel supply. The distribution of reserved forests has not been satisfactory. More forests on the upper reaches of valleys and steep slopes should be reserved for their protective value, and there is no harm in disforesting some of the reserved forests in the valleys for the purpose of growing field crop in the vacated land.

The boundaries of the reserved forests were not surveyed and demarcated but described by natural features. These enclose within them cultivated land, other settled land and entire

villages. Settled land has not been demarcated and a detailed map is wanting ; one-inch Survey of India map of the country is the only guide.

The conditions of reservation are that unrestricted rights of people in and over the settled land comprised within the reserved forest boundaries, have been conceded. No other rights have been recognized but civil authorities have been allowed to settle land with people within reserved forests with the consent of the Forest Department. Grazing and fire are excluded. The right of way to pockets of settled land in reserved forests cannot be denied. Jhuming is not recognized as a matter of right but is not prohibited.

Civil authorities have more often than not omitted to consult the Forest Department before leasing reserved forest land. The control of village land and villagers rests entirely with the Civil authorities. Protection and stopping encroachment into forest land have been a difficult matter. The result of dual control has not been very happy on the whole.

The demarcation of compact areas of forest land, excluding settled land where possible or including some of them where unavoidable, is a matter of great importance and immediate necessity. It is an expensive operation. A small sum of Rs. 15,000 only has been first sanctioned this year for survey and demarcation. This is a welcome beginning anyhow.

Besides the management of reserved forests and *Khas* forests, the Forest Department has been entrusted with the task of protection and disposal of 32 kinds of reserved trees that grow in private land. The control has to be slackened to avoid inconvenience to land owners. A reform is necessary and was proposed.

THE FORESTS

General.—The entire area of forests was once very rich in timber trees and other forest produce. But forests have been badly used in the past. They have been heavily worked for timber by traders, subjected to promiscuous *jhum* cultivation by indigenous hillmen and to uneconomic and wasteful sugarcane cultivation by new comers from the adjoining districts with whom good forest lands were indiscriminately settled. In the unbounded generosity of the Maharaja the inhabitants of the State had and still practically have a free run of the forests for domestic requirements and for internal trade, and lastly, the forest land in general has suffered from a lack of adequate and methodical supervision so far.

The combined effect of all the above causes has been deplorable. Excepting some gregarious sal and garjan in the western lower hills, which perhaps cold not be altogether destroyed, tree forest of fair density is rare. The bulk of the forest in the hills is an almost uninterrupted stretch of dense bamboo in many places, and nearly the whole of the remaining forest consists of a few trees distributed very wide apart, the intervening space being filled by thatch, bamboo or groups of secondary coppice shoots and scrub jungle consisting mainly of *Eupatorium* sp. with a tangled mass of climbers ; the ravines are lined with trees. It is presumed that where there was previously a big proportion of bamboo mixed with trees pure bamboo forest came up after felling and jhuming, soil being also perhaps more favourable to bamboo ; where density of trees was fair, groups of poles sparng up from stumps with scrub and bamboo ; where trees were sparce *Eupatorium* sp. and thatch replaced all other growth. In the valleys the composition is not different except that savannahs, i.e., tall grass and reed—occupy swampy land and trees like *Barringtonia* sp. fringe the *beels*. Stretches of close forest are only seen at places far away from floating streams, and even such are rare.

The above gives a rough picture of Tripura forests. The condition of reserved forests is not very different from that of unclassed forests except that a slightly greater proportion of trees exists in the reserved forests.

Broadly the forests may be classified into the following types :—

(1) Bamboo forests.

(2) Sal forests,

(*a*) Paddy field type.

(*b*) Highland type.

(3) Garjan forests.

(4) Mixed evergreen—deciduous forests,

(*a*) Hill type,

(*b*) Valley type.

(5) Evergreen and savannah.

(1) *Bamboo forests.*—A great many hills are completely covered with a dense growth of pure bamboo, trees being seen only in the ravines. The slopes of many other hills are also under bamboo except that scattered trees are dotted over bamboo. Bamboo also forms a substantial part of the second storey and undergrowth in other types of forests.

By far the commonest species of bamboo is *muli* (*Melocanna bambusoides*), the next in abundance are *parua* (*Bambusa teres*) and *mirtinga* (*Bambusa tulda*), *kalyai* or *kalisari* (*Oxytenanthera nigrociliata*) comes third and is found in closely tufted clumps as undergrowth in shady places, *dolu* (*Teinostachyum dullooa*) is seen as an associate of the first and the second named above, but not in profusion, *rupai* (*Dendrocalamus longispathus*) and *pecha* (*Dendrocalamus hamiltonii*) seem scarce and are only occasionally found.

(2) *Sal forests.*—Sal occurs only in the southern half of the western low hills and extends up to the boundary of E. Pakistan on the west. The elevation of the sal forest land on the boundary is not much higher than the level of the adjoining paddy land. It rises to nearly 250 feet in the eastern limits of sal ; the distance between the eastern and western limits is about 15 miles as the crow flies. Within these limits sal occupies only the eastern and western fringes covering about 6 miles, the intervening space being devoid of sal. The quality of sal in the two areas in distinctly different and hence the sal of the two areas will be separately described below. In each of these two areas again sal occurs in small and big blocks. These are separated from one another by small and fairly big distances, the space between being occupied by miscellaneous species scrub jungle, cultivation and habitation. In the sal areas sal avoids badly drained soil in which soft wooded species occur. People have built their homesteads in several places within sal forests by making clearances.

(*a*) The sal forests near the western boundary may be called the paddy land sal as they grow in land at about the same level with paddy land and nowhere more than 50 feet above it. The forests consist of sal poles not bigger than 3 feet in girth, the majority of them are crooked and none more than about 35 feet tall. Most of the stems appear to have come up from stumps. The density is high. These forests have been ill used by people living within and near them for house posts, agricultural implements and fuel ; such thoughtless action is perhaps one of the reasons for the absence of big girth and good straight stems. The forests are separated into north and south halves by about 4 miles of cultivation and raised ground coming in the middle. The quality of sal is slightly inferior in the southern part to that in the northern region. The soil seems to be slightly more lateritic in the south and the ground slightly lower ; perhaps the southern part is also subjected to more heavy grazing. All these might have combined to cause a slight lowering in the quality.

Regeneration is fair and in places profuse, but the seedlings are burnt down to the ground level annually by forest fire. Leaf-mould is almost absent due to fire.

There is no lower storey but undergrowth which is thin and not more than 10 feet high. The miscellaneous species growing in association with sal are cut as soon as they become big enough to come of any use to the neighbouring population. The associates and undergrowth will be described hereafter.

The grazing of cattle causes damage to regeneration. It is controlled to some extent by issue of permits on payment of fees but the number of head of cattle permitted to graze is not limited. The forests are subject to annual leaf-fire, perhaps started to by graziers. Damage is also caused by climbers.

(*b*) A much better quality of trees is found in the eastern part of the sal area which is high land, raised up to 250 feet. This is a different type of sal. As has been said before, not a single sal tree exists in the gap between the two main blocks of sal for no apparent reason. Sal trees in this part are straight and tall, 70 feet and higher with a clear bole of about 35 feet. Sound trees of big girths up to 8 feet are seen. Poles of good shape are found in number but saplings seem to be in deficiency. Regeneration in suitable areas is not wanting. This quality of sal covers a big area, but the continuity is broken by, as mentioned before, miscellaneous forest, scrub jungle and cultivation according to the nature of soil and natural features. Climbers infest the area, some of them are very thick and cause considerable damage. Damage by fire and grazing is as in the forest described under (*a*), but grazing seems less heavy. The associates of sal are many ; the important are the following. Some of them are much sought after by local people.

Kanak (*Schima wallichii*), *bahera* (*Terminalia belerica*), *haritaki* (*Terminalia chebula*), *sidha jarul* (*Lagerstrœmia parviflora*), *jam* (*Eugenia* spp.), *herguza* (*Dillenia pentagyna*), *koroi* (*Abbizzia procera*), *harish* (*A. stipulata*), *moroi* (*A. odoratissima*), *A. lucida, awal* (*Vitex* spp.), *khemta* (*Chukrasia tabularis*), *rangi*, or *poma* (*Cedrela toona*), *gamar* (*Gmelina arborea*), *chamal* (*Artocarpus chaplasha*), *dewa* (*Artocarpas lakoocha*), *bella* (*Sapium baccatum*), *rita* (*Sapindus mukorossi*), *kukya tetoi* (*Dalbergia* sp.), *Derris robusta*, *neur* (*Bursera serrata*), *kayengla* (*Garuga pinnata*), *kajikara* (*Odina wodier*), *bazana* (*Zanthoxyum budrunga*), *kum* (*Careya arborea*), *Stereospermum chelonoides*, etc., etc., and bamboo, such as *muli, parua, rupai*.

There are other species which do not grow tall enough to reach up to the top canopy. Being shade bearing species they thrive fairly well in this condition. Some of them are as follows :—

Pichla (*Grewia microcos*), *naricha* (*Mœsa ramentacea*), *rowatuti* (*Cordia fragrantissima*), *bela* (*Semicarpus anacardium*), *sheora* (*Streblus asper*), *Macaranga denticulata*, *Aporosa* spp., *Meliusa roxburghiana*, *Kanehan* (*Bauhinia* spp.), *Rahena* (*Dysoxylum* spp.), *Awal* (*Vitex* spp.), *Heteropanax fragrans*, *Meliosma pinnata*, etc., etc., and *kalyai* bamboo.

The following commonly compose the undergrowth :—

Bhat (*Clerodendron infortunatum*), *Leea* spp., *Desmodium* spp., *Flemingia* spp., *phutki* (*Melastoma malabathricum*), *pichas ban* or *bantulsi* (*Eupatorium* sp.), some Acacias and Mimosas, *Mallotus* spp., *Curcuma* spp., etc., etc.

(3) *Garjan forests.*—The existing garjan forest is small, but there are indications that garjan used to be found throughout the area in groups. Single stems are found even now in many places throughout the area. Small groups of garjan are still found near Khowai and Dharmanagar in the north and near Champaknagar and Sonamura in the west. Garjan also occurs in soil similar to that of sal and close to sal forests. It mixes with sal in the border where groups of both species grow close to one another. It is a gregarious species like sal. Garjan forests of appreciable size are now only found in the south western part of the State. These forest lands mostly belong to *talukdars*. Fortunately garjan is a reserved species and

as *talukdars* are usually allowed the right to first refusal in the sale of the reserved species they have used their influence to a certain extent to protect garjan in their land. A continuous stretch of forest is not found but it occurs like sal in groups and strips in scattered blocks. The total area of garjan forests is not, however, more than, say, 5 square miles in all.

Garjan is a stately tree and perfectly cylindrical in shape. A clear bole of 50 feet is common, giving a superb appearance to the forest. Patches of closely packed poles, saplings and regeneration are present in gaps between two groups of mature garjan and also in the periphery of such groups. Groups of poles were thinned last year. The associates and undergrowth are the same as in sal forests and need not be repeated here. Garjan forests are subject to the same kind of injury from climber, fire, grazing and destruction by man as sal forests are.

(4) *Mixed Evergreen—Deciduous forests.*—(*a*) Hill type :— (i) The character of the vegetation existing now on the hill slopes has already been broadly described. Individual trees, green and dead, are found scattered over the area. In the space between them is pure thatching grass with a few saplings and coppice shoots or scrub jungle mixed with bamboo and coppice-stems in various proportion, or *Eupatorium* sp. Other scrub and bamboo overgrown with climbers are common in recently *jhumed* areas. *Chheras* (hill-streams) are usually marked by a line of trees on either bank. The trees belong both to the evergreen and deciduous type according to aspect and to the proximity to water. More evergreen than deciduous species are found on cooler aspects, but nearly all are unfit for timber ; they have been left because they are too hard to cut, malformed or are of inferior species that withstood the effect of *jhum* fire. Some of the trees standing on precipices may yield good timber if they can be successfully felled and brought down undamaged to the floating streams in level land below.

The species are usually *sidha jarul* (*Lagerstrœmia parviflora*), *Stereospermum chelonoides* and *chinensis*, *khemta* (*Chukrasia tabularis*), *simal* (*Bombax malabaricum* now called *Salmalia malabaricum*), *Aral* (*Vitex* spp.), *Hymenodictyon exelsum*, *Stephegyne parvifolia*, *Nauclea sessilifolia*, *ramdala* (*Duabanga sonneratioides*), *gamar* (*Gmelina arborea*), *tula* (*Tertameles nudiflora*), *koroi* (*Abizzia procera*), *morii* (*Albizzia odoratissima*), *belfoi* (*Elæocarpus* spp.), *udal* (*Sterculia villosa*), etc., etc. A few *sundi* (*Alseodaphne owdenii* and *Michelia montana*), *chalmugra* (*Hydnocarpus kurzii*), *ashok* (*Saraca indica*), are seen on banks of steep streams. *Agar* (*Acquilaria agallocha*) is extremely rare.

(ii) Local variation in the nature of soil has produced some difference in the quality of timber ; trees in the western hills are of inferior quality in general. Also, some species which are found in the eastern hills are not seen in the western part, such as *agar* (*Aquilaria agallocha*), *sundi* (*Alseodaphne owdenii*), *chalmugra* (*Hydnocarpus kurzii*), etc. It is not possible to say definitely that they never existed in this part, as record is very meagre. A more thorough examination of the forests is necessary to come to a conclusion.

Charilam and Tulakona forests come under this group. They are completely surrounded by villages, rendering protection a very difficult matter. Tulakona being close to Agartala town, demand on it for forest produce is very heavy. These forests grow on hillocks and are more of a dry type than wet. The density of forests is fair. Several patches of thatch and *Eupatorium* sp. exist. Undergrowth is thin. *Jhuming* is still a current practice.

Regeneration of good species is seen here and there in small numbers only. It hardly gets any chance to grow due to fire and grazing.

Fire, grazing and climbers cause damage as in other forests but grazing is particularly heavy as in the western sal forests.

The forests are composed of, among other species, the following :—

Sidha (*Lagerstrœmia parviflora*), *hargaza* (*Dillenia pentagyna*), *koroi* (*Albizzia procera*), *Flacourtia cataphracta*, *Polyalthia simiarum*, *Hymenodictyon excelsum*, *sonal* (*Cassia fistula*),

Engelhardtia spicata, *Erythrina indica* or *stricta*, *bella* (*Sapium baccatum*), *dhup* (*Canarium bengalense*), *simal* (*Salmalia malabaricum*), *udal* (*Sterculia villosa* and *alata*), *kukya tetoi* (*Dalbergia* sp.), *kum* (*Careya arborea*), *awal* (*Vitex* spp.) *Nauclea sessilifolia*, *Stephegyne parvifolia*, *bahera* (*Terminalia belerica*), *amlaki* (*Phyllanthus emblicæ*), *Eugenia* spp., *tula* (*Tetrameles nudiflora*), etc., and *chamal* (*Astocarpus chaplasha*) which grows on slopes only.

Among those forming the lower storey are *kurcha* (*Holarrhena antidysenterica*), *pisla* (*Grewia mecrocos*), *mon* (*Randia dumetorum*), *Gardenia* sp., *barun* (*Cratæva religiosa*), *Litsœa* spp., *sheora* (*Streblus asper*), *Macaranga denticulata* and *Mallotus albus*, etc. Clumps of *kalyai* bamboo (*Oxytenanthera nigrociliata*) from a part of the lower storey in Charilam, *muli* bamboo being a rare commodity, where as in Tulakona, *muli* makes up a fair proportion of the forest.

(*b*) *Valley forests.*—Valley forests have been specially attacked by timber merchants and almost completely destroyed. Small samples that remain are in remote areas from which extraction to floating streams is difficult and costly. Ujanmachmara forest on the water parting of Juri and Narijuri is an example. There may be some near the source of Deo and Monu (that is, on the watershed between Myani and Kasalang on the Pakistan side and Monu and Deo on the Tripura side) which could not be visited for various reasons. Small strips are seen in the Kulai valley and Teliamura and in the remote parts of the valleys of Atharamura.

The forests are composed of a greater number of evergreen species than deciduous. The canopy is very close due to the presence of a middle storey. The trees are tall and straight and of excellent quality. These small forests give an idea of what Tripura forests used to be. A middle storey consisting of poles and evergreen shade—bearing species cover the gaps in the top canopy. Undergrowth is also thick. Regeneration has not been particularly marked but from a rapid survey the impression is that it is poor.

The species of value found *chamal* (*Artocarpus chaplasha*), *Bischofia javanica*, *Hibiscus macrophylla*, *sundi* (*Alseodaphne owdenii*, *Michelia montana* and *Talauma phellocarpa*), *Sapium baccatum*, *sutrong* (*Lophopetalum fimbriatum*), *chhatian* (*Alstonia scholaris*), *jarul* (*Lagerstrœmia flosreginæ*), *rata* (*Amoora wallichii*), *ramdala* (*Duabanga sonneratioides*), *nageswar* (*Mesua ferrea*), *jinari* (*Podocarpus neriifolia*), *kao* (*Garcinia cowa*), *Holigarna longifolia*, *Sterculia alata*, *hatia* (*Chukrasia tabularis*), *Dysoxylum binectariferum* and *D. hamiltonii*, *kurta* (*Palaquium polyanthum*), *neur* (*Bursera serrata*), *gamar* (*Gmelina arborea*), *kawatuti* (*Cordia fragrantissima*), *kayengla* (*Garuga pinnata*), *gondroi* (*Cinnamomum cecicodaphne*), *tula* (*Tetrameles nudiflora*), *Eugenia* spp., *Vitex* spp., etc., etc., *meda* (*Trewia nudiflora*) which is found on banks of streams and *Salix tetrasperma* in wet land ; agar (*Aquilaria agallocha*) is rarely seen.

Among the middle storey are innumerable evergreen species, e.g., *chalmugra* (*Hydnocarpus kurzii* and *Gynocardia odorata*), *kum* (*Careya arborea*), *chalta* (*Dillenia indica*), *bhubi* (*Baccauria sapida*), *kui* (*Bridelia retusa*), *ashok* (*Saraca indica*), *kanchan* (*Bauhinia* spp.), *Aporosa* sp., *mon* (*Ramdia dumetorum*), *Acronychia laurifolia*, *Zanthoxylum budrunga*, *Walsura robusta*, several species of Lauraceæ, etc., etc., and several kinds of bamboo especially *muli* bamboo.

The undergrowth is made up of, besides woody species mentioned under sal forest, palms, tree ferms and canes namely, *ramgua* (*Pinanga gracilis*), *Livistonia jenkinsiana*, *chhatipat* (*Licuala peltata*), *kittapat* (*Phrynium imbricatum*), *mutra* (*Clinogyne dichotoma*), *tarapat* (*Alpinia nutans*), *gandhamatrika* (*Homalomena rubescens*), *shunti* (*Cucuma* sp.) and canes, such as *galla* (*Deamonorops jenkinsianus*), *sundi* (*Calamus guruba*), *jali* (*Calamus tenuis*), *etc*.

(5) *Evergreen and savannah.*—Savannah or tall grass and reed, is found in wet land fringing swamps. There are several big swamps in the valleys near Sonamura, Kakraban, Teliamura, Kulai, Kanchanbari, etc. The savannah consists of *khagra* (*Saccharum spontaneum* and *procerum*) and *nal* (*Phagmitis karka*) mainly, but there are other species less abundant but more valued such as *ekra* (*Erianthus ravaneae*) and *tarapat* (*Alpinia nutans*) which is fodder grass for elephants. In bogs grow *hogla* (*Typha elephantina*), *mutra* (*Clinogyne dichotoma*) and also *tarapat* (*Alpinia nutans*). In firm soil outside the enclosure of grass and mixed with it are trees such as *hijal* (*Barringtonia acutangula*), *Salix tetrasperma*, *Macaranga denticulata*, *Mallotus albus*, *Aporosa* sp., etc.

Natural regeneration.—The state of natural regeneration was shortly noticed in the forgoing description of forests. The majority of good species of trees have not reproduced themselves sufficiently ; some have, but seedlings have not received help, and the conditions for growth and reproduction are not propitious. In valleys the reproduction is poor, in bamboo areas regeneration of tree species is smothered, but in grassy areas seedlings of *chamal*, *Hymenodictyon excelsum*, *kadam* (*Anthocephalus cadamba*), *udal* (*Sterculia villosa* and *pallens*) and *simal* (*Salmalia malabaricum*) are noticed. Those of *gamar* (*Gmelina arborea*) in certain areas, *jarul* in west areas and *meda* on banks of streams are not uncommon. A close examination is, however, necessary to find out what exactly precludes reproduction of good species.

ARTIFICIAL REGENERATION

An experimental plantation was started some 17 years ago at Hatipara, about 5 miles from the town of Agartala. *Gamar*, *sal* and *jarul* are the species successfully raised, the total area to date is about 300 acres. But the reproduction or extension of forests by plantation was not adopted as a policy and labour difficulty was another cause, so that no plantation was made in the forest.

The propagation of plants that yield minor forest produce, such as tan-bark, medicinal fruit and stem, etc., may be considered. It may be possible to grow them under trees, or some lands not particularly wanted for tree forest may be set apart for the purpose.

The worst enemy is man. He destroys trees and regeneration by indiscriminate felling for trade and burning for his *jhum* crop. Fire may not be considered separately as it is caused by man either intentionally or thoughtlessly ; accidental fires are not many as compared to intentional fires. Climbers are the next item of importance.

Climbers do damage in all forests, except perhaps in bamboo forest, but especially in moist forests in the valleys and in sal and garjan forests. Many trees are distorted and poles and saplings are smothered. The species that do most damage are *Ficus* spp., *Spatholobus roxburghii*, *ghila* (*Entada purseetha* or *E. scandens*), *Delima sarmentosa*, *Bauhinia anguina*, *Dalbergia* sp., *Sabia limoniacea*, *Milletia pachycarpa*, *Mucuna pruriens*, *Acacia* sp., *Smilax* sp., *Dalhousia bracteata*. Climber cutting is undertaken in sal forest at present but on account of paucity of funds very little work can be done.

Scrambling and climbing shrubs such as *pichas ban* (*Eupatorium* sp.), cover vast *jhum* areas and form an impenetrable mass of thicket preventing reproduction of any other tree or shrub and kill even grass.

Epiphytes and parasites like *Ficus* spp. *Loranthus scurrula*, *Viscum* sp. do some damage to trees. *Loranthus scurrula* specially selects *gamar* as its host tree inhibiting growth and ultimately destroying it in time.

Grazing is another item. Cattle keep down regeneration, both by browsing and trampling. Fire comes in its wake. Damage from this cause is particularly marked in the forests of the border, specially in sal and garjan forests.

Land-slides and floods are not a serious matter for consideration in the area.

AGRICULTURAL CUSTOMS AND WANTS OF POPULATION

Hill people live in huts built entirely of *muli* bamboo, a bundle of *muli* bamboo serves as post and *muli* leaf is often used as a roofing material. They live by shifting cultivation commonly called *jhuming*, burn dry sticks or bamboo to cook their frugal meal and wear clothes woven by females with home spun yarn. A *takkual* (a sort of bill-hook) is the only agricultural implement wanted by them being suitable both for cutting and digging.

People who live in the valleys and plains practise plough cultivation. By far the majority of them are Bengali moslem settlers. They want some fuel wood, bamboo and timber for agricultural implements, house posts and furniture and thatch for roofing. Well-to-do people live in towns ; their principal demand is fuel wood besides some timber, bamboo and thatching grass. The demand in any case is not heavy and is easily met. But the people of the sourrounding districts of Pakistan also draw their requirement of forest produce from the forests of Tripura. This demand is heavy.

MARKETS AND MARKETABLE PRODUCTS

The principal commodities in demand for local consumption and supply to the adjoining districts of Pakistan are bamboo, specially *muli* bamboo, thatching grass, fuel, house posts and timber for agricultural implements, house building and common furniture. Cane is also an important article in demand but it has disappeared having been uprooted and exported in war-time. *Chhatipat* (*Licuala peltata*) leaves are locally used as cover for bamboo umbrellas and are also exported to Pakistan.

Besides the above, medicinal herbs, fruits, bark and root are collected in small quantities and exported to Calcutta. Of these chalmugra fruit is the most important item of export. Agar wood (*Aquilaria agallocha*), from which a valuable scent is prepared, and *gandhamatrika* rhizomes (*Homalomena rubescens*), which is mixed with tobacco for flavour, have their market also at Calcutta ; the former has been over exploited in the past leaving very little for the present generation.

Kalyai (*Oxytenanthera nigrociliata*) and *muli* (*Malocanna bambusoides*) bamboos are exported to Titagarh for paper pulp, and thin sticks of *muli* are either made into umbrella handles locally and exported, or unfashioned bamboo sticks are exported to Calcutta. As local people have not got to purchase forest produce the real markets for forest produce are in the adjoining districts of Pakistan. Bamboo mats and containers of rice are articles of cottage industry commonly manufactured by hillmen and exported to Pakistan markets.

Timber, fuel and thatch are exported to Pakistan in great quantities. Some dugouts are also exported.

The abundance of bamboo seems to justify setting up a paper mill or a crushing mill if only communication can be improved quickly.

LINES OF EXPORT

The lines of export are streams and innumerable foot-paths. The principal streams are Longai, Juri, Deo-Monu, Dhalai, Khowai, Howra, Salda, Gumti, Kakri Muhuri and Feni.

There are no roads except the Sonamura–Simna road but innumerable paths lead to Pakistan villages and bazars. Forest products meant for the Calcutta market are sent via Pakistan Railway which is close to the boundary.

Streams are the highways of traffic with the interior, but the traffic of heavy forest produce, i.e., timber has to be seasonal for the following reasons. Only a few streams are navigable throughout the year. Even those that are navigable are not deep enough to allow of floating logs except in the rainy season. In other streams water rises in the rains barely sufficiently to make the transport of only bamboo rafts possible.

METHOD OF EXTRACTION

There is no forest road or cart-track. Timber as a rule is not sawn in the forest but round logs are dragged by elephant and other produce borne on shoulder and brought to the floating streams ; thereafter they are transported to the border by water. Bamboo bundles and small house posts are also carried on *holla* pulled by a buffalo. This is a framework on which one end of posts and bamboo rests and the other end trails along the ground. Thatch is floated-down on bamboo rafts. Where there is no stream close by, people carry forest produce on shoulder all the way to the border and beyond the border to the market-place. Sometimes pack ponies are used.

COMMUNICATION AND BUILDINGS

Communications are not easy. There is no railway-track within the boundaries of the State but the East Pakistan Railway skirts the western and northern border. Sonamura–Simna road via Agartala and the Udoypur road which joins it at Melagarh are the only means of communication with some of the outlying districts. Other districts are not linked with the headquarters town of Agartala by road but by footpaths only. An excellent tar macadamized road connects Agartala with the Pakistan railway station of Akhaura which is only 5 miles from it. Other principal towns which are almost all built close to the border may be approached from Agartala through the Pakistan Railway or on foot following tracks. People have to use foot-tracks for internal communication.

Forest staff is poorly housed. No substantial house is built anywhere. At very few places the forest staff has family quarters provided for them. The houses built are on mud-plinth with bamboo walling and thatch roofing. Usually at each station there is one such house in which the officer lives with his forest guards and his office. The house is often in bad repair. This is very unsatisfactory. Government servants who have to live 12 months of the year in out of the way places should have at least creature comforts. The officer living in the same room with forest guards can hardly command respect and maintain discipline. There is no forest rest-house for inspecting officers except in towns.

STAFF

Forest subordinates are not trained in forestry and they are poorly paid. Having remained always employed in the collection of toll or royalty they have learnt to detect toll dodgers but they have no love for the forest. Only very few are capable of hard outdoor work. Forest Guards are ease-loving and lazy and the majority of them are physically unfit for strenuous work. Under the circumstances the introduction of a new method of work with the existing staff who do not take kindly to the new task has become a difficult problem.

A beginning has been made to train those among the existing staff who are educationally fit to receive training and are comparatively young in age. As vacancies occur new recruits are

sent to the forest school at the expense of Government for training before employment. This is a slow process but there is no help for it perhaps.

It may be profitable to sanction the re-employment for 5 years of some trained personnel who have recently retired from Government service. It is hoped that with their help it may be possible to make a beginning of regeneration and other scientific forest works in a systematic manner in every range while recruits are getting training in school.

It is also necessary to delegate sufficient executive and controlling powers to forest officers according to their rank to enable them to discharge their duties efficiently and promptly in the interest of the forests.

PAST SYSTEMS OF MANAGEMENT

It is mentioned above that the subjects of the Tripura Raj were allowed by the generous ruling power the privilege to fell and use forest produce free of royalty to whatever extent desired. The same privilege was also enjoyed by tacit consent by Bengali settlers and those coming to the State for temporary residence. They gradually began to trade in forest produce within the State for personal gain without payment of royalty. This unlawful practice escaped the notice of the authorities. The privileges of the indigenous people, including such concessions as *jhuming*, remain unrestricted even to this day. The privileges of the inhabitants have, however, been now partly limited in respect of the use of timber in as much as certain species have been reserved to Government. They are required to pay royalty for the use of the reserved species of trees even though taken from their own land.

Forest revenue constitutes about a third of the total revenue of the State. The bulk of it is derived from the forest produce that is taken out of the State into Pakistan for sale, in which case no forest produce is exempt from royalty. But no royalty is charged for forest produce sold within the State, traders thus make a profit by selling commodities to which they have not acquired a proprietary right by paying royalty.

So far forests have been worked for highest revenue. In the year 1887 certain rules were framed with a view to preservation and improvement of trees in reserved forests. But it does not appear that any area was declared as reserved forest. Therefore, it is unlikely that all of those rules were ever applied. In those rules 7 species were named as reserved to Government and were perhaps given some protection. It appears that some or all of these species used to be treated as reserved even before the issue of the notification, although there was no written order to this effect. By "Reserved tree" was only meant that a royalty was payable for it. In 1903 certain other rules were framed with a view to regulate the collection of forest produce and payment of royalty thereof.

In 1913 a comprehensive set of rules was drawn up. Tripura State was divided into several forest *mahals* or Sub-divisions in regard to forest revenue, and the procedure for the collection of revenue was laid down. Several kinds of hammers, such as marking size, sale and property hammers were devised and rules framed for their use. 32 species of trees were now reserved; tree species were classified into 7 classes according to their relative value. A limit was put to the size below which no tree might be felled. There was, however, no limit to the quantity that might be felled and removed per annum. But merchants were required to apply for a permit stating the number of trees they would like to fell and extract; the permit fee varied according to the quantity wanted.

Originally there was no restriction to the felling and export of trees and bamboos, provided a toll was paid. The revenue was collected by Government agency or by revenue

farmers. Even after the introduction of felling rules the revenue of forest *mahals* in respect of timber and bamboo used to be farmed separately, subject to the observance of rules, for a number of years at a time to the highest bidder. The revenue farmer naturally encouraged the felling and extraction of forest produce to the greatest extent possible for profit during the term of the lease. Later the system was discontinued and revenue of timber and bamboo was collected by Government agency ; for less important forest produce such as thatch, honey, medicinal products, etc., the *mahals* continued to be leased as before.

The rules were good on the whole but it all depended on how those rules were observed by the public and enforced by subordinates. The omission to fix a yield and lack of provision for concentrated felling rendering stump checking and supervision difficult, were indeed serious drawbacks. But notwithstanding such drawbacks it was possible to diminish wasteful felling to a certain extent by strict observance of the rules of marking and felling. But two things worked against applying effective control ; Government was happy to get more and more revenue from excessive fellings and the ill-paid forest subordinates were happy to make illegal gain by simply omitting to do their appointed duty ; the more clever ones even received commendation from Government for collecting high revenue. Forest subordinates seldom visited forest to mark trees for felling as was required by rules but marked logs on the river bank or at forest *ghat* offices. As regards the conduct of timber-traders, there was a scramble for who should put his property hammer mark on a good tree first. The result was that more trees than could be floated were cut and streams were literally blocked with logs. Many were carried away beyond the State boundary by heavy flood and escaped payment of royalty.

As regards bamboo there was no restriction whatsoever to the quantity to be cut or to the season or place of cutting. The result is that due to over-cutting bamboo has been either killed or impoverished in easily accessible areas so that culms have become much thinner than before.

Cane is an important item of forest produce in the economy of local people. It was clear felled or uprooted during war time, rhizomes were, therefore, killed by exhaustion. Cane is now a rare commodity.

What with unauthorized felling and what with unrestricted *jhuming* the supply of timber is rapidly dwindling to a very small quantity and the quality of bamboo is becoming poor. The obvious remedy was to give rest to forests by restricting exploitation and to stop *jhuming*. Three years ago a limit was sought to be fixed to the quantity that might be annually felled. It was only an average of the past few years outturn yet the attempt was unsuccessful. India Government has recently imposed customs restrictions on the export of timber. It indirectly helps the forest cause. As the greater part of timber annually collected is meant for export the cutting is likely to be much less than usual.

The forest revenue which forms a large slice of the total revenue of the State is not likely to be sustained long at the high level now reached, as the producing capital, the growing tree, is being destroyed.

The *jhumia* problem is of vital importance to the progress of this State. If hillmen are to live and prosper they must be taught to use the plough and the spade, and settled on fixed cultivation leaving off jhuming. The wanton destruction of forest, year after year, in the process of *jhum* cultivation, has a prejudicial effect on agriculture and river transport. The country being hilly it is necessary that hill slopes should remain covered with forest, otherwise soil is washed from surface and brought to the stream below.

Two alternative suggestions were forwarded to Government with a view to eliminating *jhum* cultivation from the State or at least from the reserved forests.

SUMMARY OF FACTS PREJUDICIAL TO FORESTRY

It has been clearly shown in the foregoing pages that the forests have been wantonly destroyed by *jhuming* and over exploitation in the past for revenue, and it is undesirable to extract forest produce in future to the extent removed so far.

Defects requiring immediate attention are summarized below :—

(1) *Jhuming* has caused destruction of forest.

(2) Dual control of forest land and lack of a map and demarcating boundary line are a cause of gradual destruction of forest and diminution of forest area.

(3) Forests have been over-exploited in the past and, therefore, the revenue derived from forest produce was abnormally high, but—

(4) Bamboo is now not being fully utilized.

(5) As no forest road exists the extraction of forest produce to the streams is costly and inspection difficult.

(6) Except experimental plantation no systematic regeneration work was undertaken for lack of funds and suitable staff.

Not much attention has so far been given to minor forest produce.

(7) Forest buildings are flimsy and insufficient.

(8) The existing forest staff is unsuitable and its pay inadequate.

(9) Powers delegated to the forest officers are inadequate.

THE SEASONING BEHAVIOUR OF INDIAN TIMBERS

PART I

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SUMMARY

The importance of adopting proper methods of seasoning wood before use is emphasized. The advantages of seasoning are also discussed. The air and kiln seasoning behaviour of fir is described, and the kiln drying schedule recommended for 1" thick planks of fir and for several other light hardwoods suitable for packing cases, is given.

INTRODUCTION

A considerable amount of data on the air and kiln seasoning properties of Indian woods has been collected by the Wood Seasoning Branch in the last thirty-five years during the course of experiments carried out at Dehra Dun as well as in the field in different parts of the country. Systematic accounts of the results of most of the air drying tests have been published from time to time but not much information has so far been published by this Institute on the kiln drying studies of timber. The object of the present series of publications is to present all available information on air and kiln drying of Indian timbers, as well some information on the availability, uses and important properties of these woods.

It is hardly necessary to emphasize the importance of seasoning wood before use, particularly in this country where climatic conditions are very trying for wood-work in most parts, and where a large variety of woods, mostly of a refractory nature, are found.

Seasoning as applied to wood is primarily a drying process. It is not a method of preservation of timber. Freshly felled timber contains a large quantity of moisture, the major portion of which has to be removed before the timber is fit for use for most purposes. Timber shrinks as it dries, for this reason anything made out of unseasoned wood will not retain its shape and size ; the components of finished article are likely to warp, twist and crack. Dimensional stability and elimination of defects are not the only advantages of seasoning wood before use : there are several other advantages besides. Seasoned wood is stronger than green timber, it is lighter in weight, is less liable to attack by moulds, fungi and insects (as food material is depleted or transformed), and it responds better to wood working tools and takes finish and polish better.

The degree of seasoning to be given to wood depends upon the service requirements and the climatic conditions of the locality where the wood is to be used. For high class work such as cabinet making, panelling, and other indoor uses, the wood should be thoroughly seasoned to a moisture content which is in equilibrium with the atmosphertic humidity of the locality (10% to 12% moisture content suits the greater part of this country). For outdoor uses such as poles, bridges, railway sleepers, etc., partial drying of timber to about 25% moisture content is considered reasonable, as it is not possible in practice to wait for long periods for the air seasoning of thick material to be completed, though thorough air drying is desirable.

There are two commercially important methods of seasoning wood practised in this country, viz., air seasoning (natural seasoning) and kiln drying (artificial seasoning). Both are equally good, speaking in general terms. In the process of air seasoning the timber to be

dried is properly stacked and left to nature for drying. Certain precautions to protect the wood from hot winds and sun should be taken while seasoning refractory hardwoods. The process of kiln drying is carried out in a seasoning kiln which is a chamber, usually made of masonry and heated by means of steam or smoke gases, and in which the desired conditions of temperature and humidity of the air can be maintained. A rapid circulation of air may also be maintained around the timber being seasoned with the help of fans, or the kiln may have only thermal circulation. Kiln seasoning is a method of quick drying of timber to any desired moisture content under controlled conditions of temperature and humidity. For this reason many timbers which are likely to get damaged in air seasoning can be dried satisfactorily in a seasoning kiln.

Due to the absence of any large wood-using industries till the World War II, with the exception of a few railway workshops and ordnance factories, much attention to seasoning of wood before use was not paid in this country. However, the war gave an impetus to the establishment of several timber industries, particularly the manufacture of plywood, packing cases, ammunition boxes, shuttles, bobbins, various kinds of handles, and a variety of small items. The importance of seasoning was recognized and several commercial seasoning installations came up, besides those put up by State Departments using timber.

In the more advanced western countries the seasoning installation (air seasoning sheds, conditioning rooms and seasoning kilns), is an essential complement of every timber yard, saw-mill and wood-working concern. Further, every timber industry has developed a technique of its own for seasoning wood which it finds the best and the cheapest. In fact seasoning is considered almost synonymous with industrial development and the seasoning installation forms almost one-third part of every large wood-working factory. It is very important that proper attention to seasoning wood before use should be given by all the wood-using industries of this country also, if they want to compete with the imported articles and if Indian timbers are not to be placed at a disadvantage, and for the sake of conserving forest resources.

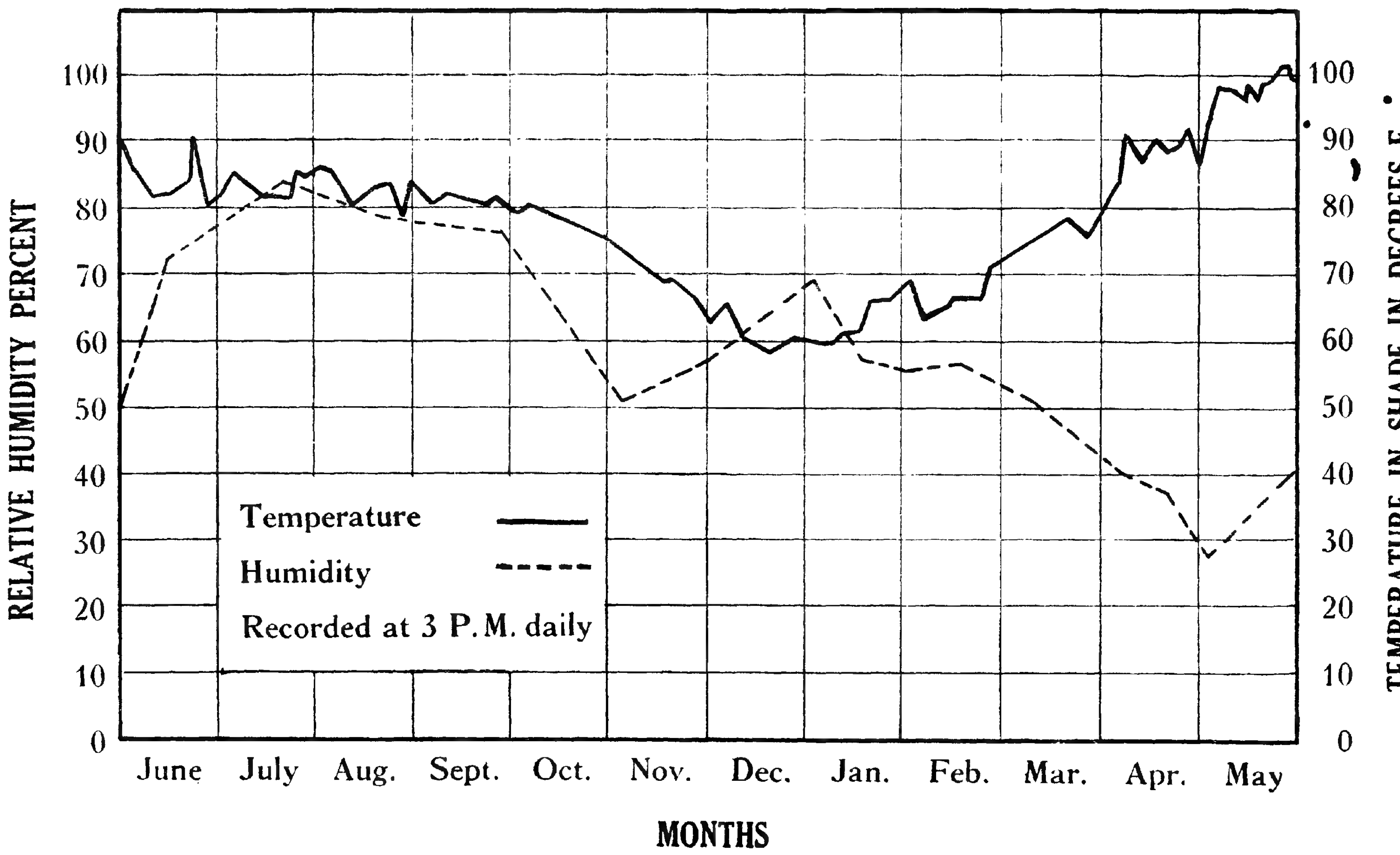
Most of the air drying tests of which the results are reported in the publications under issue were carried out at Dehra Dun in a proper type of air seasoning shed on timbers received from different parts of the country as logs, which were converted at site. Some of the earliest drying experiments as well as most of the experiments on the air seasoning of railway sleepers were of course carried out either in the forest or in the nearest depots in the plains. In applying the results of air seasoning tests carried out at Dehra Dun, it should be noted that the locality has a mild climate and the timber under seasoning is not subjected to severe drying conditions, except during the short summers. The accompanying chart gives an idea of the temperature and humidity of air under shade as recorded at 3 p.m. daily in a well ventilated veranda over a period of one year in Dehra Dun.

With the progress in the wood-working industries in the country, greater interest is now being shown in kiln drying techniques as well. For this reason the information available on the kiln drying characteristics of Indian timbers is also being presented as well as tentative kiln drying schedules for different woods tested at the Forest Research Institute, Dehra Dun.

The kiln drying schedule is a guide chart with respect to the temperature and humidity conditions to be maintained in the kiln when the moisture content of the wettest samples of wood on the entering air side in the kiln has reached the stage specified in the schedule. For the sake of brevity, temperatures and humidities in these series are indicated as 45°C/75% R.H., which means a temperature of 45°C and a Relative Humidity of 75 per cent of the circulating air.

It may be remarked that the kiln schedule is only a rough guide for running a seasoning kiln while drying a certain species of timber at a particular moisture content. The schedule

TEMPERATURE AND RELATIVE HUMIDITY OF ATMOSPHERE AS RECORDED IN AN AIR SEASONING SHED IN DEHRA DUN.



is to be regulated in the light of the progress of drying, formation of moisture pockets, quality of timber, purpose for which timber is required, type of kiln, and several other factors. For this reason the operation of a seasoning kiln should be entrusted to a trained technician.

CHAPTER 1

Abies pindrow (fir)

Availability.—Found in Kashmir, Punjab (India). Himachal Pradesh, Uttar Pradesh and the Nepal Himalayas.

Properties.—A non-durable light timber, the average weight at 12% moisture content being about 29 lb. per c.ft. Easy to saw and work, and can be brought to a smooth finish. A light, moderately strong and soft wood.

Air seasoning.—Easy to air season as planks. Thick scantlings are liable to end-splitting and surface cracking in the early part of drying process if exposed to sun and hot winds.

Fir planks, one inch in thickness, stacked outside in the open in winter months in Dehra Dun dried down from 40% to 16% moisture content in six weeks. Ordinarily one inch thick planks of this wood will take about 2–3 months for seasoning under cover.

Seasoning of railway sleepers.—Fir usually comes to the plains in the form of sleepers (10′ × 10″ × 5″ in size), or as scantlings of various dimensions for the general market. These are floated down the streams and rivers from the hills.

The extraction in the high hill forests where this timber grows starts sometimes about April after the snow has melted, and goes on till about November. Timber cut from April to August which reaches the launching depots at the foot of the hills by the end of rains is floated down the streams in the month of August. Sleepers cut from September to November remain at the launching depots or sometimes in the forest at stacking depots till August next year when they are floated down. The sleepers float for about three or four months before they reach the depots in the plains.

From the above it will be seen that the converted sleepers remain stacked in the forest for several months before they are floated down. It has been observed that the splitting in sleepers actually starts in the forest even on the high hills if the sleepers are exposed to sun even for a few days. Any subsequent care in handling in the plains will not help much if the sleepers start in the split and cracked condition from the forest.

During the course of various tests carried out in the forest it has been found that fir sleepers (10′ × 10″ × 5″ in size) cut sometime in July and kept stacked in close crib manner at the launching depots for about four months dry down from 40% to average moisture content of about 17%, the moisture content of the outer layer of wood at this stage being about 14% and in the interior of the sleeper about 20%. The sleepers cut from September to November and kept in close crib manner at the launching depots or in the forest at rope-way heads till the following October were found to have come down to 15% moisture content. The tests on air seasoning of fir sleepers carried out in Dhilwan (Punjab) showed that the sleepers had on an average, a moisture content of about 45% when they reached the depots in the plains at the end of flotation. The moisture content of individual sleepers varied from 80% to 27% in this case.

The experimental sleepers were stacked in December in "1 and 9" method for air seasoning in the open yard at Dhilwan. Their average moisture content was found to have come down from 45% to 15% in seven months, but the timber was not thoroughly seasoned in the interior. The sleepers took about a year for complete seasoning to 12% moisture content. The surface cracks and end-splits were found to have closed up at the end of seasoning. The application of a moisture retardant composition like coal-tar to the ends of sleepers helped in reducing damage due to end-splitting during drying.

Kiln seasoning.—Fir is easy to kiln dry in the form of planks but kiln seasoning of thick scantlings takes a long time and is uneconomic. Thin planks for packing cases or for other general use can be quickly seasoned under a drastic kiln schedule. One inch thick planks were seasoned from 56% to 15% moisture content in 60 hours in an internal fan kiln.

SCHEDULE I

Tentative schedule for one inch thick planks of Fir†*

Moisture content of timber on air inlet side	Temperatures				Relative Humidity %
	Dry Bulb		Wet Bulb		
	°C	°F	°C	°F	
Green	52	125·6	44	111·2	62
60%	55	131·0	45	113·0	55
40%	60	140·0	46	114·8	44
30%	65	149·0	48	118·4	39
20%	68	154·4	48	118·4	33·5

The timber is not liable to develop case-hardening, therefore, high humidity treatment is not considered necessary at any stage. Initial steaming of the charge for about 2 hours at 55°C/100% R.H. may be carried out to sterilize the wood.

For aircraft work, slower seasoning of wood at lower temperatures and higher humidities than those given in the schedule is recommended. For instance, one inch thick planks of this wood should be kiln dried in 6 to 7 days. The drying should be started at 45°C/70% R.H., and towards the end of drying the temperature of the circulating air should be near about 55°C and Relative Humidity about 45%.

The timber should be given the final conditioning treatment by working the kiln at 50°C/85% R.H. for at least 6 hours in case of one inch thick planks for aircraft work.

Uses.—Fir is an ideal packing case timber. It is suitable for tea chest battens, battery separators, moulded picture frames and slate frames. Treated timber is used for railway sleepers. Properly selected timber can be used for aircraft work as substitute for Sitka spruce. Other chief uses are house-building, planking, shingles, roofing, opium chests and ammunition boxes, general carpentry and rough furniture, light co-operage (particularly dry), ordinary boards, foot rules, match splints and water troughs.

* For timber more than one inch in thickness, the relative humidity should be kept 5% higher at each stage during seasoning.

† See Appendix I.

APPENDIX I

List of timbers to which the Schedule I is applicable

		Weight per c.ft. (air-dry) in lb.
1.	*Ailanthus excelsa*	27
2.	*Ailanthus grandis* (*gokul*)	25
3.	*Ailanthus malabarica*	23
4.	*Alstonia scholaris* (*shaitan* wood)	26–30
5.	*Bombax insigne* (*didu*)	24
6.	*Bombax malabaricum* (*semul*)	25
7.	*Canarium euphyllum* (white *dhup*)	26–28
8.	*Duabanga sonneratioides* (*lampati*)	24–30
9.	*Erythrina suberosa*	17–20
10.	*Excœcaria agallocha* (*geon*)	24
11.	*Ficus glomerata* (*gular*)	25
12.	*Gyrocarpus jacquinii* (*punki*)	20–26
13.	*Lophopetalum wightianum* (*banati*)	26–30
14.	*Moringa pterygosperma*	19
15.	*Parishia insignis* (red *dhup*)	24
16.	*Picea morinda* (spruce)	29
17.	*Sterculia alata* (*narikel*)	24
18.	*Sterculia campanulata* (*papita*)	21
19.	*Sterculia villosa*	17–20
20.	*Tetrameles nudiflora* (*maina*)	20–24
21.	*Trewia nudiflora* (*gutel*)	22–26

FLOWERING HABITS OF THE BAMBOO—*DENDROCALAMUS STRICTUS*

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Deogun (1) has aptly summarized all available knowledge regarding the flowering habits of *Dendrocalamus strictus* when he calls it an "irregularly flowering bamboo". He has added that in the case of this bamboo "one or a few culms in one clump or a few clumps in one locality (sporadic), or all culms in one clump and all clumps in a certain area (gregarious) may flower". The writer visited some of the bamboo forests in Lansdowne (U.P.), Beas (Punjab), Angul (Orissa) and Balaghat (Madhya Pradesh), divisions during the last winter in connection with the All-India co-operative bamboo experiments. The following notes are based on the observations made during that tour.

GREGARIOUS FLOWERING

The bamboo forests near Kotdwara (Lansdowne division) flowered gregariously in 1919 and are again flowering in the Paniali block since 1948. This suggests a life cycle of 30 years for the locality. No case of gregarious flowering at Nauri (Lansdowne division), Talwara (Beas division) and Jaganathpur (Angul division) is on record. The extreme case is that of Talwara and the other properly managed Government bamboo forests in Hoshiarpur and Kangra districts where the species has probably not flowered since 1846, and definitely not during the last 65 years (2).

SPORADIC FLOWERING

Sporadic flowering, as opposed to gregarious flowering is a more or less continuous phenomenon everywhere. Cases of this type of flowering were met with in all the localities visited. The intensity was noticed to change from place to place and even from one part of the forest to the other. The climatic, edaphic and boitic factors which aggravate drought conditions appear to favour it. Whereas the cases of partly flowered clumps were quite common in some places—Talwara and Balaghat—they were practically non-existent in others—Jaganathpur and Nauri. In order to throw further light on the matter, the data collected in connection with the All-India bamboo plots, referred to above, have been examined. Here, a large number of clumps have remained under observation over a period of 15 years, and, among other things, a careful record about the flowering of individual clumps has been maintained. The results of this analysis are presented in the following two tables :—

TABLE I.—*Showing the total number of clumps flowered and the number of clumps that flowered in part only*

Particulars	Name of plot				
	Nauri, Lansdowne division	Barapahar division	Jaganathpur, Angul division	Batkari, Balaghat division	Talwara, Beas division
1. Total number of clumps under observation ..	700	550	500	500	900
2. Number of clumps flowered (in part or whole) during the period 1934-47 ..	221	21	33	19	32
3. Percentage of the flowered clumps to the total number of clumps	31·6	3·6	6·6	3·8	3·6
4. Number of the clumps which flowered only in parts and survived flowering ..	27	8	13	11	22
5. The above expressed as percentage of the total number of flowered clumps ..	12·2	38·1	39·4	57·9	68·8
6. Number of clumps which produced new culms in the year of flowering	60	10	17	12	22

PHOTO 1.—*Dendrocalamus strictus* clump in Reserve Talwara, C 4 (Beas Forest Divn.) with 3 new culms and 3 dead ones which flowered in 1940. One of the flowered culms is held by the Forest Guard.

PHOTO 2.- A small bamboo clump dug up from Reserve Batkari C. 696 with only 5 culms, 3 of which (on the right) flowered and died in the past. Out of the living two, the younger one, which is 2 seasons old and is held by the Forest Guard, is in flower. The older living culm adjoining this is still normal in appearance.

PHOTO 3.—Two culms dug up from a close clump in the same locality. The clump had 21 culms, two of which were new. The culm on the right (3 4 years old) started flowering in 1949 and continued doing so in 1950 when it also sent out the new culm (on the left). Its top portion placed side by side shows the 1949 flowers now partly shed (labelled as No. 1) and the 1950 flowers

TABLE II.—*Showing the number of clumps flowering during the various calendar years*

Year	Name of Plot				
	Nauri, Lansdowne division	Barapahar division	Jaganathpur, Angul division	Batkari, Balaghat division	Talwara, Beas division
1934	14	1	9	..	1
1935	16	..	..	..	3
1936	19	3	3	2	..
1937	14	4	4	..	2
1938	11	..	4	5	1
1939	23	..	2	4	1
1940	16	3	1	2	1
1941	19	3	1	1	7
1942	15	1	6	..	4
1943	16	2	..	2	11
1944	15	4	1	2	1
1945	6	4	..	1	..
1946	26	..	2	..	..
1947	11	1	2	..	..
	..	26	33	19	32

The crops in all the above plots originated from natural regeneration. It is, therefore, highly probable, that many of the above clumps may have originated from more than one seedling. The experimental clumps which had survived flowering, as well as a number of those actually in flower in the locality at the time of the visits, were examined. This examination revealed that although many of the clumps might be composite ones, some at least, are too small to admit of that possibility (Photo 1). A number of the partly flowered clumps were dug up and, in most cases, the connection of the flowering culms with the underground rhizome of the clump was established. Photo 2 shows a small clump dug up from Reserve Batkari and consisting of 5 culms, only two of which were alive. The younger of the two was in flower and the older appeared to be quite normal. The dead culms, apparently, had flowered and died during the last 2–3 years. Another clump consisted of 21 green culms, two of which were new. Only one mature culm, about 3 years old, was in flower and the rest of the clump looked normal. A portion of the clump was dug up and the flowered culm was found to have originated from the common rhizome system (Photo 3). This culm first flowered in 1949, and put forth fresh flowers, on separate branchlets, in 1950. The branchlets bearing the 1950 flowers were green and living, while those which flowered in 1949, were dead. Another interesting point is that the rhizome of this culm gave rise to a new culm simultaneously in 1950. Some more cases of clumps flowering in part during the successive years were also noticed.

It thus appears that the periodicity of the gregarious flowering of the bamboo *Dendrocalamus strictus*, in some localities, is more than 65 years, and may possibly be over a century. So far as sporadic flowering is concerned its behaviour is extremely irregular. The intensity of flowering varies from locality to locality, and from year to year, in the same locality. The whole clump may flower in one year and die, or only a few culms may be affected, leaving the remainder apparently normal. Portions of the same clump may flower in successive years. The phenomenon of the partially flowering clumps is quite common in some localities and is comparatively rare in others. The flowering culms may be of any age and may not, necessarily, be the oldest in the clump. Normally the culms die after flowering, though some of these may flower for two successive years.

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GREGARIOUS FLOWERING OF A COMMON HILL BAMBOO *ARUNDINARIA MALING*, GAMBLE

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SUMMARY

Periodicity of flowering in bamboo and the stages of establishment of a new seedling crop form interesting subjects of study. *Arundinaria maling*, Gamble, the commonest hill bamboo of Darjeeling hills has flowered gregariously this year. Gregarious flowering in this species has never been recorded earlier. The present article deals with the nature of flowering and gives a systematic description of the bamboo with flowers.

Occurrence of flowering and fruiting, as is well known, is a memorable occasion in the life history of a bamboo. Unlike the other members of the plant kingdom, that flower and seed almost regularly every year, the periodicity of flowering in bamboos is a phenomenon that normally attracts more attention of forest officers and botanists. The morphological characters of the flower, the changes that the clumps undergo preceding and succeeding the flowering and stages of development and establishment of the seedling crop form interesting subjects of study. Informations have been collected on a few of our important bamboos but majority of them still remain to be explored.

The year 1951 has seen the gregarious flowering of *Arundinaria maling*, Gamble, the commonest hill bamboo of the Eastern Himalayas, all over the Darjeeling hills. The bamboo is found every where in the upper hill forests of West Bengal and also in Nepal and Sikkim between 5–9,000 feet, and is morphologically different from high level *Arundinaria recemosa*, Munro, which grows between 7–12,000 feet. The latter species is locally known as *Sanu maling*, and is known to reach a maximum height of 4′–6′ only.

The local name '*Maling*' is extremely familiar with the common people who use this small bamboo for a variety of purposes. There is a good market for bamboo mats made out of *Maling*, which is extensively used as roofing material and for temporary partition walls, floors and nursery sheds. The culms are used for fences and young leaves are in great demand as cattle and pony fodder. This bamboo is suitable for paper pulp and is being tested for its suitability as cheap umbrella handle. It comes up gregariously on exposed forest land, particularly on ridges, and invades burnt areas practically to the extinction of other species. The gregarious nature of the species often becomes a problem in many clearfelled areas, where the bamboo has got to be cut down frequently to afford proper protection to seedlings. It is a natural colonizer of exposed soil and has been found to be one of the first to come up on areas badly affected by landslip and erosion. Like other bamboos, however, this is highly inflamable and is responsible for many a forest fires in these hills, when it acts as a ladder for the ground fire to creep up to the crown.

Although sporadic flowering has possibly been noticed at intervals, as far as could be ascertained locally, gregarious flowering over a vast tract of country has not been witnessed before, at least in the living memory. This is a further corroborated by the fact that no such records could be traced out by the Silviculturist, West Bengal and the Forest Botanist, Forest Research Institute, Dehra Dun. Troup in his 'Silviculture of Indian Trees'—Volume III, page 1000 and Brandis in his 'Indian Trees' report likewise. A morphological description of the flower was published in October issue of *Indian Forester*—Volume LV, 1929 by

Mr. E. Blatter. No record is, however, available of the fruit which evidently shows that the specimens collected were in a year of sporadic flowering, and possibly the flowers were sterile.

The writer who had the opportunity of observing the different stages of gregarious flowering and fruiting of the species, and made a systematic morphological study, considers it necessary to put it on record for facility of forest officers and botanists who might be interested in this bamboo.

Flowering.—The gregarious flowering of 1951 was preceded by a sporadic flowering of the bamboo in 1950 and was observed by the writer particularly in Senchal range all round the Tiger hills, Darjeeling, when he happened to be stationed there as Divisional Forest Officer. This once more proves the correctness of our silvicultural knowledge about the necessary preliminary to a gregarious flowering. Clumps over extensive areas were, however, seen to be in flower in February–March, 1951, and the climax of flowering was observed in April–May, when every clump, big or small, was in flowers. As a preparatory to flowering, the culm had shown considerable yellowing. The fruiting started towards the latter half of May and has continued till the middle of June.

Morphological Description

Arundinaria maling, Gamble.—An erect gregarious shrub with short perennial underground rhizome. Culms-erect, single–stemmed, fistular with a thick wall, generally 10–20 feet high with 0·5″–1·5″ diameter. Colour green to ashy, sometimes with reddish tinge, indistinctly ribbed, scaberulous, internodes-scabrous, above 12–15 in long.

Culm-sheath-straw coloured, 7–10 inches long, chartaceous—coriaceous, prominently striate with ciliate margin, broad, auriculate ; blade—subulate, 2–3 inch long, scabrous inside ; ligule—fimbriate. Leaves—alternate, linear-lanceolate, sub-sessile, attenuate into a short petiole, glabrous, acuminate, margin finely serrate, blade 3″–6″ × ·25″–·75″ ; nerves 3 pairs, veins forming rectangles with nerves. Sheaths-striate, provided with few long rigid bristles ; ligule-short, ciliate.

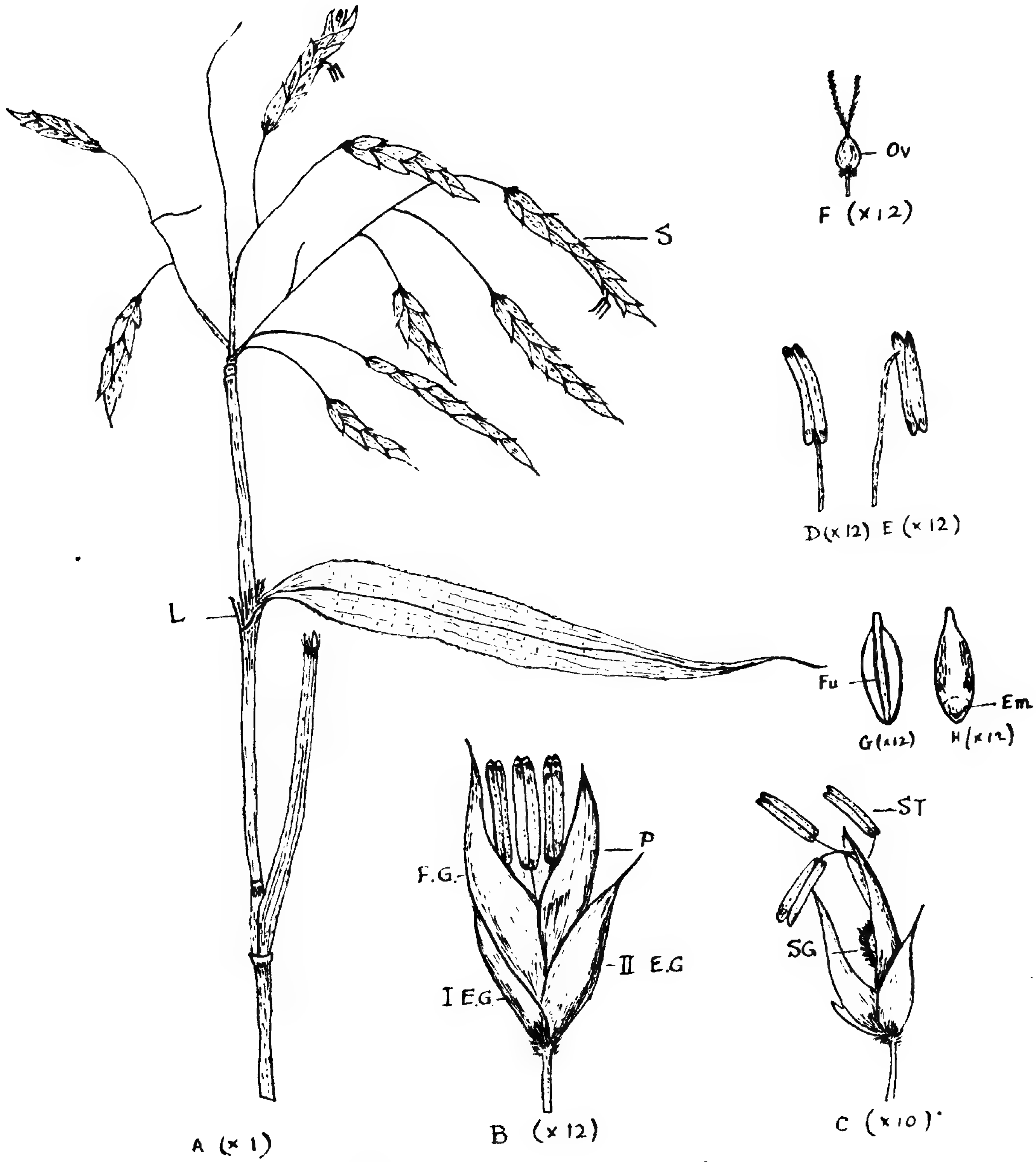
Inflorescence.—A panicle of spikelets, provided at the base with a spathaceous and higher up with foliaceous sheating bracts. Rachis-angular and glabrous, rachilla-thin, filamentous and sinuate. Spikelets—5–15 in number, 2 inches long, enclosed at the base by two empty glumes, one placed a little above the other embracing the lowest flower, glumes-ovate, setaceous, acuminate, pinkish-red. Flower—5–12 in each spikelet, 0·5–1 cm. long, provided with :

(*a*) *Flowering glume.*—which is green, large, striate, boat-shaped, scabrous, setaceous-acuminate. 1–1·2 cm. long, covering the flower in bud or fruit when mature, and,

(*b*) *Palea.*—slightly shorter than flowering glume, boat-shaped, 2-keeled and bifid at apex, 2–3 nerved with veinlets, 7 to 8 m.m. long. Flower—hermaphrodite, perianth represented by 3 small lodicules, ovate, acute.

Stamens—3, free, prominent and protruding out of flower when mature, colour yellow to greenish yellow, filaments delicate and twisted round each other, Anther dorxifixed, 2-chambered, dehiscence through slits at the tip ; pollen-minute, powdery, white. Carpel—1, ovary superior, 1-celled, globose, much shorter that stamens, hairy at the base ; stigmas-2, long, plumose.

Fruit—caryopsis, ·3 cm. long, Seed albuminous ; grain dorsally furrowed, included within persistent flowering glume and palea.



ARUNDINARIA MALING Gamble

Immediately after the flowering the clumps started showing evident signs of drying up and death. The leaves dried up quickly and the culm turned yellow. Monthly observations made from July to September showed increasing mortality, the latest observation made in Mahaldram block of Kurseong forest division revealed that practically every culm that flowered had died without exception. No cases of coming up of new shoot from old rhizome could be seen. It is also interesting to observe that though the flowering was profuse, the seeding has been comparatively very poor. New regeneration from seeds have not yet come up. Though contrary to general rules, cases have been recorded by Troup in *A. falcata* and some other *Arundinarias*, where bamboos have been seen to flower without dying even when flowering takes place at long intervals, it cannot be said with certainty if the rhizomes in this species will completely die. The future behaviour of this common hill bamboo as to its propagation will form an interesting study.

It will also not be out of place to record in this connection that *Arundinaria aristata*, a member of the same genus, generally found at altitudes above 10,000 feet in E. Himalayas, had been seen to flower gregariously in Darjeeling division in 1950.

EXPLANATION OF PLATE

A—Upper part of culm with panicle, leaf and ligule.
B—The lowermost flower in a spikelet showing the position of glumes.
C—A flower when fully open showing relative position of stamens and stigma.
D—A stamen as seen in its normal position.
E—Stamen showing insertion of filament to anther.
F—Carpel—highly magnified.
G—Grain with glumes removed showing furrow.
H—Grain showing position of embryo.
S—Spikelet L—Ligule.
I E.G. 1st empty glume II E.G.—2nd empty glume.
F.G.—Flowering glume P—Palea.
ST—Stamen (anther) SG—Stigma.
OV—Ovary FU—Furrow EM—Embryo.

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NOTE ON *SALIX ALBA* (CRICKET-BAT WILLOWS) AND WICKER WILLOW-EXPERIMENTAL PLANTING

BY MALIK KHEM CHAND MALHOTRA

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1. *Introductory.*—As a result of partition, mulberry plantations were all left behind in West Punjab ; and, thus, the sports industry in the East Punjab (India) received a serious set-back. Therefore, to rehabilitate the industry, the Forest Department has been anxiously experimenting on the production of the best possible timber material for it.

2. *Experiments and results.*—Cricket-bat willows (both English and Kashmir varieties) and also Wicker willow were obtainable only from the high altitude forests of Kashmir ; and 600 branch cuttings of the Cricket-bat willow of both the varieties were imported from Srinagar by aeroplane and planted out in Manali nursery (Kulu) in spring of 1949. They gave 95% success, with 5 feet average and 9 feet maximum height during the first growth-season. From the stock thus raised, branch cuttings and transplants were put out elsewhere under forest conditions in Kulu forest division. Again, during the spring of 1950, another 900 branch cuttings of the Cricket-bat willow (both English and Kashmir varieties) were imported from Srinagar and planted out in Manali nursery. These more than confirmed the previous year's experiments by yielding cent-per-cent success. Besides, 100 branch cuttings of Wicker willow (noted for basket-making), imported and planted along with the Cricket-bat willow, also gave nearly cent-per-cent success from the stock thus raised in the nursery. Again branch cuttings and transplants were obtained and put out in the forests of Kulu, Seraj and Kangra forest divisions with likewise very encouraging results, particularly at altitudes above 6,000 feet.

3. *Proposals for future.*—Again during the spring of 1951, 467, 469 and 187 branch cuttings of English and Kashmir Cricket-bat willow and Wicker willow respectively were likewise obtained by aeroplane from Srinagar and planted out in Manali nursery, 22, 21 and 22 respectively in Jutogh Cantonment forest nursery and 10 cuttings of all the above three species together in the compound of Port-More Government Girls' High School at Simla. The success was nearly cent-per-cent in all the cases, with 1½′ to 3′ height in Manali nursery by the middle of July, 1951. On account of the certainty of success in the cultivation of the above mentioned willows in the hills of the East Punjab, but on account of heavy cost, botheration and serious restrictions imposed recently by the Kashmir Government on the import of the willow stock from Srinagar, it has been decided to raise our own stock from the current year's planting by extension in Manali and Jutogh nurseries, which will serve as a perennial source of cuttings and transplants on a large scale. And it has been done accordingly during this monsoon. Spare but extensive enough blocks of the two nurseries have been set apart for this purpose. And branch cuttings from the entire stocks in the two nurseries have been put out in those blocks.

4. *Silvicultural note.*—The English Cricket-bat willow variety of *Salix alba* is called *Cœrulea*. Leaves of this willow are shorter than those of the Kashmir variety. Stubs (cuttings or stumps) should be up to wrist-thickness and 4½′ long, pointed at bottom and turned off flat (not wedge-shaped) at the top. This should be planted 2′ deep underground and 2½′ out. The average rotation is 12–14 years. The most suitable time for planting is winter, but early spring also gives good enough success. The leaves of the Wicker willow are thinner and softer than these of *Salix alba*.

INDIGENOUS CELLULOSIC RAW MATERIALS FOR THE PRODUCTION OF PULP, PAPER AND BOARD

PART VI.—WRITING AND PRINTING PAPERS FROM PAPER MULBERRY (*BROUSSONETIA PAPYRIFERA*)

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SUMMARY

Experiments conducted in Madras State and Travancore-Cochin State indicate that paper mulberry (*Broussonetia papyrifera*, Vent.) can be easily raised in plantations from seeds. The species reproduces itself naturally and is a fast grower and a good coppicer. The bast fibre is used in Japan for the preparation of extremely strong and high quality papers. Laboratory experiments as well as pilot plant trials carried out in this Branch indicated that the wood of this species is a useful raw material for the production of writing and printing papers. Since the chemical pulp from this wood is short-fibred, an addition of about 25% of long-fibred pulp such as bamboo pulp in the furnish improves the strength properties of the paper.

INTRODUCTION

"A Preliminary Note on *Broussonetia papyrifera* (The Paper Mulberry)" issued by this Institute in 1947 discusses the possibilities of establishing plantations of this species in this country. This note gives useful information including the distribution and general characteristics of the species, its cultivation, and the results of plantations raised in Dehra Dun and elsewhere. *Broussonetia papyrifera* is a native of the Indo-Malayan region, China, Japan and the Pacific Islands. It occurs in Upper Burma along the Salween river, south of the Karenne country and Martaban extending to Siam. This species is cultivated in gardens in Saharanpur, Calcutta and Lahore and has been tried in Dehra Dun and Saharanpur *taungya* areas. In Punjab it has become established in some of the irrigated plantations where it has spread naturally from seed and root-suckers. It is an exotic, and has not been raised in the forests of this country in quantities sufficient for industrial exploitation.

This species is one of the easiest to raise artificially. Direct sowing gives satisfactory results but stumps and transplants are probably the safest. About 1 oz. of seed will be enough to transplant about 4 acres at $6' \times 6'$ espacement. Stumps of $0{\cdot}3''$ to $0{\cdot}4''$ diameter at the collar with $1{\cdot}5''$ of shoot and $9''$ of root give the best results.

It regenerates itself profusely by seed (through the agency of birds), by root-suckers and also by coppice. It establishes itself rapidly in light well-drained sandy loamy soil. It does not thrive under heavy grass. Once it is established, it often takes possession of the ground and is difficult to eradicate. Measurements carried out in the Demonstration Area of this Institute indicate that a yield of six tons of wood (air-dry) can be expected from one acre of plantation on a rotation of ten years ; but in areas of higher rainfall a higher yield can no doubt be expected.

According to the information supplied by the Chief Conservator of Forests, Travancore-Cochin State, to the Silviculturist of this Institute, the plantation experiments carried out in that State have given encouraging results. A *taungya* plantation of paper mulberry, 2/3 of an acre in extent, was raised with a crop of paddy in Koni Division in June 1949. The seedlings were raised from the seeds supplied by the Silviculturist of this Institute and the Provincial Silviculturist, Ootacamund. The casualties were 4% in October 1949, and the plants averaged 3–4′ in height at that time. By April-May 1950 the growth was so good that the *taungyadar* could not raise a second crop of paddy on account of the shade of the paper mulberry plants. In November 1950 a sample plot of one sq. chain was measured and the mean of 120 plants gave an average girth at breast height of 9″ over bark and an average height of about 18′. A few outstanding trees both inside and outside the sample plot showed an average girth at breast height of 19″ over bark and a height of about 28′. The soil was not alluvial but it was a good, well-drained, forest soil. The elevation of the place is about 200′ and the rainfall about 120″.

An investigation on the chemical pulping of the wood of this species for the production of writing and printing papers was undertaken in this Branch. The results of this investigation are recorded in this bulletin.

THE RAW MATERIAL

The Silviculturist of this Institute supplied the raw material for these experiments from the Demonstration Area of this Institute. Trees of the age of 8–12 years were felled and cut into logs of 8–16′ length. These logs varied in diameter from 3·5″ to 12″. The logs were debarked and chipped in the factory chipper (Waterous Ltd., Brantford, Canada) of this Branch. The chips were sieved on the factory screen (Waterous Ltd., Brantford, Canada) and the sieved material was used for these experiments. The factory chipper has four knives. The screen has two sieves of different meshes. The top sieve is 0·5 mesh and the bottom sieve 3·5 mesh.

PROXIMATE CHEMICAL ANALYSIS

The chips were reduced to dust in a laboratory mill, size 8″ (Gallenkamp, London). As usual the dust passing through 60 mesh and retained on 80 mesh was used for the proximate chemical analysis employing the methods[1] used at Madison except in the case of pentosans where TAPPI standard T 223m-48 was used. The results of the proximate analysis are given in Table I.

TABLE I

Proximate Chemical Analysis of the Wood of Broussonetia papyrifera

		% on the oven-dry basis except moisture
1.	Moisture	5·48
2.	Ash	1·08
3.	Cold water solubility	4·20
4.	Hot water solubility	7·93
5.	1% NaOH solubility	17·96
6.	10% KOH solubility	30·59
7.	Ether solubility	0·99
8.	Alcohol-benzene solubility	1·92
9.	Pentosans	16·43
10.	Lignin	23·26
11.	Cellulose (Cross and Bevan)	59·18

From these results it will be seen that the cellulose content of this wood is quite satisfactory for its utilization for the production of paper pulp. The results of the alkali solubilities indicate that high yields of pulp will be obtained from this wood by the alkaline pulping processes. This is borne out by the results of the sulphate pulping experiments reported later in this bulletin.

FIBRE DIMENSIONS

The fibre length and diameter of the chemical pulp from this wood were determined by the usual methods followed in this laboratory. The fibre length of the pulp varied from 0·54 to 1·2 mm. with an average of 0·82 mm. The average fibre diameter was found to be 0·0302 mm., the minimum and maximum values being 0·0174 and 0·0465 mm. respectively. The ratio of the average fibre length to diameter was 27 : 1 ; the value of this ratio is very small compared to some of the indigenous hardwoods examined in this laboratory.

PRODUCTION OF PULP

A number of laboratory digestions were carried out by the sulphate process using 20–26% chemicals on the over-dry weight of the raw material in a concentration of 45 g. per litre at 153–162°C. for 6 hours. For the digestions caustic soda and sodium sulphide were used in the ratio of 2 : 1. The digestion conditions, bleach consumption, pulp yields and strength properties of standard sheets made from bleached pulps are given in Table II.

DISCUSSION

It will be seen from the results recorded in Table II that easy bleaching pulps with satisfactory strength properties can be prepared from the wood of *Broussonetia papyrifera* by the sulphate process. The yields of unbleached and bleached pulps are satisfactory. The bleach consumption is higher when less quantity of chemicals (20%) is used. Under the conditions studied the digestion conditions of Serial No. 3, Table II, give pulps with the best strength properties. The digestion of the wood with 24–26% chemicals (on the basis of the oven-dry raw material) in a concentration of 45 g. per litre at 153–162°C. for 6 hours is suitable for the production of well cooked pulps in high yields and with satisfactory strength properties. Since these pulps are short-fibred, an addition of 25% of long-fibred pulp such as bamboo or sabai grass pulp in the furnish will be necessary for a successful run on a commercial paper-making machine. Since the bark of paper mulberry is noted for long fibres, admixture of the pulp from the bark may be helpful in improving the tear of the paper.

PILOT PLANT TRIALS

In order to confirm the results of the laboratory experiments regarding the suitability of the wood of paper mulberry for the production of writing and printing papers, three large scale experiments were carried out on the pilot plant of this Branch. In each case about 600 lb. (on over-dry basis) of chips were used and the digestion was carried out by the sulphate process using 26% of chemicals (*on the basis of the oven-dry raw material*) *in* a concentration of 45 g. per litre at 162°C. for 6 hours. The yields of the unbleached and bleached pulps were 52·7% and 48·6% respectively and the bleach consumption 8·8% of standard bleaching powder ; all these quantities are expressed on the basis of the oven-dry raw material. The pulp from one experiment was beaten, the requisite quantities of rosin size, alum and China clay were added, and used for making printing paper on the Fourdrinier machine described earlier[2]. The pulp from another large scale experiment was used for another run of

printing paper after mixing it with 25% of bamboo pulp. The strength properties of these two papers are given below :—

Strength properties of printing papers from paper mulberry (pilot plant trials)

	Printing paper from 100% paper mulberry bleached pulp	Printing paper from a mixture of 75% paper mulberry bleached pulp and 25% bamboo bleached pulp
1. Freeness, c.c. (C.S.F.)	180	185
2. Ream weight in lb., 20″ × 30″—500 ..	27 ·4	27 ·3
3. Basis weight*, g./sq. metre	59 ·8	60 ·0
4. Thickness, mils (1/1000 inch) ..	3 ·45	3 ·55
5. Tensile strength (Schopper), kg. per cm. width		
(*a*) Machine direction	2 ·88	3 ·40
(*b*) Cross direction	1 ·47	1 ·86
6. Breaking length*, metres		
(*a*) Machine direction	4750	5670
(*b*) Cross direction	2420	·3490
7. Stretch, %		
(*a*) Machine direction	1 ·8	2 ·1
(*b*) Cross direction	3 ·2	4 ·1
8. Tearing resistance (Marx-Elmendorf), g.		
(*a*) Machine direction	25	37
(*b*) Cross direction	27	40
9. Tear factor*		
(*a*) Machine direction	41 ·4	61 ·7
(*b*) Cross direction	43 ·9	66 ·5
10. Bursting strength (Ashcroft), lb./sq. inch	16 ·7	19 ·5
11. Burst factor*	19 ·5	22 ·8
12. Folding endurance, double folds		
(*a*) Machine direction	14	54
(*b*) Cross direction	8	28

* For calculating this, oven-dry weight of the paper was used.

The papers were conditioned at 65% R.H. and 85°F. before test.

A sample each of these two printing papers is attached at the end of this bulletin.

From the results of these pilot plant trials it is clear that writing and printing papers of good formation and satisfactory strength properties can be made from bleached pulp of paper mulberry. An addition of bleached bamboo pulp in the furnish helps to run the paper smoothly on the machine and improves the strength properties of the resultant paper. It may be mentioned here that previous investigations carried out in this Branch have shown the wood of paper mulberry is a promising raw material for the production of newsprint grade mechanical pulp[3].

CONCLUSIONS

1. Easy bleaching pulps in good yields and with satisfactory strength properties can be prepared from the wood of paper mulberry by the sulphate process.

2. The digestion of the chips by the sulphate process with 24–26% of chemicals (on the basis of the oven-dry raw material) in a concentration of 45 g. per litre at 153–162°C. for 6 hours gives well cooked pulps.

3. Since these pulps are short-fibred, an addition of about 25% of long-fibred pulps such as bamboo pulp in the furnish is necessary for the smooth running of the paper on the machine.

4. Since paper mulberry is a fast growing species, can be raised easily, and is a useful supplementary raw material for the production of paper, attention should be directed by authorities concerned on raising plantations of this species in suitable forests in the vicinity of paper mills in this country.

Thanks are given to Shri V. S. Krishnaswamy, I.F.S., Silviculturist, Forest Research Institute, for having supplied paper mulberry for this investigation and for the silvicultural information contained in this bulletin.

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TABLE II.—*Sulphate digestions of Broussonetia papyrifera*

DIGESTION CONDITIONS AND PULP YIELDS

1	2	3	4	5	6	7	8	9
Serial No.	Total chemicals* NaOH : Na_2S -2 : 1	Concentration of chemicals	Digestion temperature	Digestion period	Consumption of chemicals*	Unbleached pulp yield*	Bleach consumption as standard bleaching powder containing 35% available chlorine*	Bleached pulp yield*
	%	g./litre	°C	hours	%	%	%	%
1	20	45	162	6	19·5	52·8	9·0	48·3
2	22	45	162	6	21·0	51·4	7·8	48·1
3	24	45	153	6	22·0	52·0	8·7	48·1
4	24	45	162	6	21·8	51·1	6·6	48·2
5	26	45	153	6	22·1	50·4	9·0	47·1
6	26	45	162	6	22·1	50·7	5·8	48·0

* The % is expressed on the basis of the raw material (oven-dry).

and strength properties of standard sheets

STRENGTH PROPERTIES OF STANDARD SHEETS CONDITIONED AT 65% R.H. AND 65°F.

10	11	12	13	14	15	16	17
Freeness of pulp	Basis weight	Breaking length	Stretch	Tear factor (Marx-Elmendorf)	Burst factor (Ashcroft)	Folding endurance (Schopper)	REMARKS
c.c. (C.S.F.)	g./sq. metre	metres	%			double folds	
321	59·2	7420	3·8	62·3	35·2	140	
318	61·8	7840	4·0	66·4	40·0	180	
321	63·0	9010	5·0	81·8	48·2	1200	Well cooked pulps were obtained in all the experiments recorded in this Table. The bleached pulps had a bright shade.
331	62·3	8140	4·2	71·2	46·6	280	
324	61·2	7950	4·7	68·6	42·0	550	
340	61·6	7770	4·0	81·3	41·8	400	

SOCIETY OF AMERICAN FORESTERS HAS FIFTIETH BIRTHDAY

This organization has had leading part in developing U.S. forestry as a profession; many large commercial operators follow federal and state leads in conserving natural resources, tree-planting, and woodland management practices.

BY HENRY CLEPPER

From *The Scientific Monthly*

The forest conservation movement in the United States had its inception in the last quarter of the nineteenth century. It was initiated by a small group of public-spirited citizens who demanded government protection of the nation's woodlands at a time when most people believed that forests in the United States were inexhaustible.

In 1871 the great Peshtigo, Wisconsin, forest fire in the heavily forested area of the American Midwest occurred. It was the most disastrous in the nation's history; more than 1,100 people died, and 1,250,000 acres of forest were burned. In 1872, J. Sterling Morton, of Nebraska, proposed establishing Arbor Day on which communities sponsor public tree-planting observances, and the U.S. Congress passed the Timber Culture Act. Thinking people were worrying publicly about the nation's indifferent handling of its natural resources. In 1876 Congress authorized the appointment of "a man of approved attainment and acquainted with the methods of statistical inquiry" to make an investigation and a report on forestry. Five years later the small staff which resulted from this authorization became the Forestry Division of the U.S. Department of Agriculture. Now the U.S. Forest Service, it is still a part of the Agriculture Department.

Until the close of the nineteenth century there was no profession of forestry as it is known to-day in the United States. In 1900 the School of Forestry at Yale University and the Division of Forestry at the University of Minnesota inaugurated their first formal courses in forestry. These two are the oldest forestry teaching institutions in continuous operation in the Western Hemisphere.

At the turn of the century there were few technically trained foresters in the United States. Among them were Gifford Pinchot and Henry S. Graves, who had obtained their training in Europe, several German foresters—the most prominent of whom were Bernhard E. Fernow and C. A. Schenk—and a few others. Mr. Pinchot became chief of the Division of Forestry in the U.S. Department of Agriculture in 1898, with two technical foresters and nine other employees on his staff. The Division recruited technicians from among student assistants. This corps of carefully recruited young men subsequently provided many leaders in the forestry profession.

On November 30, 1900, seven young men assembled in Mr. Pinchot's office to organize a professional society, and there formed the Society of American Foresters; eight additional members were admitted in December. Men prominent in conservation, including former U.S. President, Theodore Roosevelt (twenty-sixth President, 1901–1909), were elected as associate members. Membership now totals 6,700.

By 1918, 20 schools, most of them state institutions, offered four-year undergraduate courses in forestry. Yale had the only wholly graduate school. To-day, 22 colleges and universities have accredited schools of forestry. The training in each of these schools has a solid core of five courses: silviculture, forest protection from fire, insects and disease, forest management, forest economics, and forest utilization.

At least half the schools now offer graduate instruction leading to the master's degree. Yale and Duke universities also offer a comparatively new degree of doctor of forestry. Since

the first degree in forestry was awarded in 1900, the forestry schools of the United States have granted approximately 17,500 bachelor's and 3,000 master's degrees.

Early American foresters were handicapped by lack of knowledge of the growth, and response to treatment, of trees in forest stands. Accumulated European knowledge, based as it was on a score of commercial tree species, had little application in the United States, with its hundreds of commercial species.

In 1905, President Theodore Roosevelt signed an act transferring the forest preserves from the U.S. Department of Interior to the Department of Agriculture, thereby putting the management of the federal forests under the supervision of the government's foresters. In 1908, the federal government formulated a plan for a system of forest experiment stations, and in 1915, a research branch was established in the U.S. Forest Service. Research was conducted almost from the establishment of the first school of forestry. Some of the States undertook experimental work and set out sample plots, forestry's indispensable tool. A law, enacted in 1928, authorized a research program under the direction of the U.S. Forest Service which included a system of forest and range experiment stations, increased research in forest products, and a national survey of forest resources. To-day the federal government operates eleven regional forest experiment stations and 100 branch stations and research centres.

Studies of tree diseases are carried on by the division of forest pathology of the Bureau of Plant Industry, Soils and Agricultural Engineering, while the division of forest insects of the Bureau of Entomology and Plant Quarantine has done notable work in forest insect control.

New York was one of the first States to consider operating tree nurseries and reforestation. The States of Pennsylvania, New Hampshire, Maine, New Jersey, Ohio, Wisconsin, Michigan, Minnesota and California have forest management programs, and Oregon, Texas, and Washington State have their own research programs to study forest products utilization and wood technology.

The United States has 180,000,000 acres of government-owned forests under protection and management. These contain a third of the nation's timber stand, a sixth of its commercial timberland, nearly all the important sources of western water, and other related values, including range for livestock, recreation areas, and wildlife.

National forests in 40 States, and in Alaska and Puerto Rico came into existence in 1891, when the U.S. Congress authorized the President to set aside forest reserves. These are managed under a multiple-use system by which the land is made to serve the maximum number of uses, each integrated with the other. Timber-cutting methods, for example, may be modified to stabilize water flow, protect scenic attractions, benefit wildlife, or adjust grazing benefits. Another aspect of national forests administration is sustained-yield management, limiting the cut of timber to the sustained productive capacity of the unit. About 4,000,000,000 board feet of timber, cut annually from the national forests, now supply a little more than 10 per cent of the volume of lumber production in the United States, plus other products, including poles, mine timbers, railroad ties, and pulpwood.

Perhaps the most significant point to be noted about the economic importance of the national forests is that, with a decrease in the acreage of privately owned uncut timber, the demand for national forest timber is steadily increasing. The contributions of the national forests in grass for livestock, in water, in wildlife, in recreation, and in other benefits are of great economic importance.

In the U.S. Department of Interior, the Bureau of Land Management administers 30,000,000 acres of timberland in the public domain, exclusive of Alaska. Also under the control of the Interior Department are some 16,000,000 acres of forests of Indian lands and nearly 7,000,000 acres of forests in national parks. These forests are not maintained for commercial purposes but for the preservation of forest species and types.

Acquisition of forest land by the various States began during the last two decades of the past century. State forests now total more than 16,000,000 acres. Most state forestry agencies are supervised by trained foresters. One of the most important of their functions is the prevention and control of forest fire. Many States also assist private woodland owners in reforestation, management, and marketing of timber. Another type of publicly owned forest is the community forest-woodland owned by a municipality, township, school district, county, or other civil body. There are about 3,100 of these, many of which are for watershed protection.

According to U.S. Forest Service estimates, there are 4,250,000 private owners of commercial forest land in the United States, with a total area of 345,000,000 acres. Because forestry practiced on public lands serves numerous long-range social interests, it is seldom required to function at a profit. Farm forestry may be carried on primarily for the control of soil erosion, for protection of land by the maintenance of shelter-belts of trees, and for the production of wood supplies for home use. But forestry practiced as a commercial enterprise is a business and is as sensitive to the influence of gain or loss as the operation of any other industry.

As long as virgin timber was plentiful and costs of wood were relatively low, the practice of forestry on industrial holdings was not considered economically justified. However, with the depletion of the original timber and a consequent rise in the cost of producing wood, the competitive possibilities for practicing forestry became more favourable. Pulp and paper companies which had heavy investments in land plants were among the first to practice forestry. Other companies set about growing their own timber.

Although the economic benefits of good forestry practices on farm woodlands were advocated more than half a century ago, it was not until 1924 that a national policy of governmental assistance to farm woodland owners was adopted. Within five years, 31 States had organized co-operative extension programs with foresters to assist farmers. In soil conservation districts, U.S. Soil Conservation Service foresters are available to help farmers with woodland management problems. The industry-sponsored Tree Farm program is helping to mobilize assistance in tree-growing to woodland owners in many States. According to the Society of American Foresters, there are now about 4,000 foresters employed by industry, by other private woodland owners, and by private associations.

The Society of American Foresters, now in its fiftieth year, is affiliated with the American Association for the Advancement of Science. The *Journal of Forestry*, official organ of the Society, published monthly, is one of the world's best-known technical forestry periodicals.

Without the Society of American Foresters it is unlikely that the forestry profession in the United States would exist in its present form. By establishing standards of professional education, by supporting an adequate forest research program, by providing a forum where foresters and others may debate issues and present technical papers, by adopting a code of ethics for the guidance of foresters, by providing a scientific journal as a medium for reporting the techniques of forestry practice, the Society has adhered to its objectives—the promotion of "the science, practice, and standards of forestry in America".

END

[*This article appeared in* The Scientific Monthly, *a scholarly scientific journal published in the United States by the American Association for the Advancement of Science. The writer is executive secretary of the Society of American Foresters and managing editor of the* Journal of Forestry].

FORESTS & FORESTRY.

RECOMMENDATIONS OF THE VIII ALL-INDIA SILVICULTURAL CONFERENCE 1951.

The recommendations of the VIII Silvicultural Conference on the various topics discussed by it are given below.

I. SILVICULTURE AND ECOLOGY

A. ORGANIZATION OF SILVICULTURAL RESEARCH

The VIII Silvicultural Conference reviewed the action taken on resolutions Nos. (3), (4) and (5) of item 1 of the VII Silvicultural Conference of 1946 and being of the opinion that full effect had not been given to them reaffirms the resolutions in the following revised terms :—

Whereas

(*a*) Specialized training at the Forest Research Institute of state silviculturists and silvicultural rangers is considered essential, and such training, to be effective, requires to be systematized ;

(*b*) continuity in silvicultural research is of primary importance ;

this Conference recommends that

(i) state silviculturists and silvicultural rangers be carefully selected from among officers with not less than three years experience as divisional forest officers and range officers respectively and that for silviculturists two years additional experience as working plans officers would be a desirable qualification ;

(ii) as soon as possible after appointment, state silviculturists and silvicultural rangers should undergo specialized training at the Forest Research Institute for at least three months, part of which should fall during the monsoon period ;

(iii) state silviculturists and silvicultural staff found suitable after probation should be kept in their posts for at least five years ; and

(iv) every state silviculturist should have a trained assistant who would be capable of replacing him.

Whereas

(*a*) it is desirable to attract talented officers for manning the silvicultural posts of all grades in States and to enable them to work contentedly in their special posts ; and

(*b*) silvicultural research work is specially arduous, exacting and of a technical character ;

this Conference recommends that the attention of State governments be invited to the need for granting special pay for all staff engaged in silvicultural research.

Whereas in the interests of co-ordinated research ;

(*a*) visits by state silviculturists to the forests of other States with similar problems and to the Forest Research Institute are now even more necessary than in the past ;

(*b*) such visits have been very infrequent in recent years ; and

(*c*) the Central Silviculturist should keep in close touch with the problems of the States ;

this Conference recommends that

(i) facilities be afforded for state silviculturists to visit States where there is work going on of special importance to their own in order to gain first-hand knowledge of what is being done ;

(ii) when a problem is common to a number of States, joint tours by those interested should, if possible, be organized to study it ;

(iii) the Central Silviculturist should pay regular visits to the forests in the States in order to study local problems and give advice ; and

(iv) state silviculturists should visit the Forest Research Institute as frequently as possible in order to keep up-to-date in experimental technique and to discuss their problems.

Whereas

(*a*) modern silvicultural research extends over a wide field and has become more complex than in the past ;

(*b*) in order to obtain useful results with the minimum expenditure of time and money, it is necessary that the research division in each State should be properly constituted ;

this Conference recommends the following as a minimum silvicultural research unit :

(i) a state silviculturist who should be a deputy conservator of forests or an officer of equivalent rank ;

(ii) an assistant silviculturist who should be an assistant conservator of forests ;

(iii) one research ranger for each territorial circle ;

(iv) one research forester for each research nursery or research station ;

(v) two research foresters for each field party, and

(vi) one technically trained computor for undertaking routine computations.

The Conference further recommends that research staff of and above the grade of ranger should be given special training in the Forest Research Institute, other staff being trained locally.

Whereas

(*a*) proper documentation of silvicultural literature from India and abroad is an essential part of the work of the silviculture branch of the Forest Research Institute ;

(*b*) such work appears to have fallen into arrears, especially in respect of Indian working plans ;

(*c*) re-ledgering of existing files should be undertaken as opportunity offers ; and

(*d*) the present staff appears to be inadequate for this purpose ;

this Conference recommends that

a post of documentation officer should be created and filled by a suitable forest officer. Such additional clerical assistance, as may be required, should also be given.

Whereas

(*a*) the post of experimental assistant silviculturist in the silviculture branch of the Forest Research Institute has been in existence for a long period ;

(*b*) failure to fill this post for several years has caused dislocation of work in the branch ;

this Conference recommends that the post be filled as early as possible.

Whereas

(*a*) the existing staff in the soil section of the silviculture branch is inadequate for the current programme of work ;

(*b*) it is considered necessary that intensive study of teak and sal soils should be undertaken ; and

(*c*) no action appears to have been taken on the resolution on item No. 10 of the VII Silvicultural Conference (1946), recommending additions to the staff of that section ;

this Conference recommends that

the staff of the soil section should be strengthened as early as possible by the appointment of an assistant soil chemist, together with necessary additional subordinate research staff.

Whereas

it is considered necessary that further work should be done on the following items :—

(*a*) studies in forest genetics ;

(*b*) systematic study of exotic tree species, with a view to introducing them in India ;

(*c*) systematic study of forest soils associated with major timber types like teak, sal and conifers ;

(*d*) study of the silviculture of all species used in wood based industries ;

(*e*) special studies on the growth and development of bamboos ;

(*f*) studies in raising shelter belts and their effect on their environment ; and

(*g*) research on soil erosion and soil conservation problems in forest areas ;

this Conference recommends that

the Central Silviculturist should, in collaboration with the Forest Botanist and the Statistician of the Forest Research Institute and state silviculturists, conduct research studies on the above mentioned items.

Whereas

(*a*) it is necessary to fill up the serious lacunæ in the data available for the compilation of yield tables of even important species ; and

(*b*) the list of species for which crop yield tables are to be prepared, as drawn up by the III Silvicultural Conference (1929) needs revision for various reasons ;

this Conference recommends that

(i) the state silviculturists should, in co-operation with the Central Silviculturist, lay out at a very early date, new plots to fill the gaps in the existing data for plantation teak, sal (high forest and coppice), deodar, chir, *kail*, sissoo, *Terminalia tomentosa*, *Quercus incana* and casuarina ; and

(ii) attention should be concentrated on the following additional species and the state silviculturists should complete, as soon as possible, the laying out of the sample plots required for the compilation of yield tables for them :

I. In natural forests :

Abies pindrow, *Acacia arabica*, *A. catechu*, *Amoora wallichii*, *Boswellia serrata*, *Dalbergia sissoo*, *Dipterocarpus macrocarpus*, *Michelia champaca*, *Picea morinda*, *Quercus dilatata*, *Q. semecarpifolia*.

II. In plantations :

Acacia arabica, *A. catechu*, *Alnus nepalensis*, *Amoora wallichii*, *Bombax malabaricum*, *Casuarina equisetifolia*, *Dalbergia sissoo*, *Lagerstrœmia flosreginæ*, *Michelia champaca*, *Morus alba*, *Prosopis juliflora*, *Salix alba*, *Talauma phellocarpa* and *Terminalia myriocarpa*.

Whereas

(*a*) the accuracy of the various crop statistics determined from sample plots depends to a great extent upon the correct selection of sample trees ;

(*b*) as the crop advances in age and has received a few thinnings, the number of felled sample trees, especially of larger diameters, progressively diminishes ; and

(*c*) the only solution of this difficulty lies in measuring standing sample trees ;

this Conference recommends that

proper attention should, in furture, be paid to the measurement of standing sample trees and all state silviculturists should acquire, without further delay, one set each of the equipment necessary for the purpose.

Whereas

(*a*) information regarding outturn and rate of growth for a large number of our tree species, especially those that have come into prominence during the last two decades, is very inadequate ; and

(*b*) the list of species for which volume tables are required as drawn up by the III Silvicultural Conference (1929) is out-of-date ;

this Conference recommends that

(i) state silviculturists should, in collaboration with the Central Silviculturist, take necessary steps to compile, as soon as possible, local or regional volume tables for the following species :—

PRIORITY I

Abies pindrow.
Acacia arabica.
Acacia catechu.
Adina cordifolia.
Ailanthus excelsa.
Alnus nepalensis.
Alstonia scholaris.
Amoora spectabilis (*Amoora wallichii*).
Anogeissus latifolia.
Anogeissus pendula.
Salmalia malabarica (*Bombax malabaricum*).
Boswellia serrata.
Casuarina equisetifolia.
Cedrela toona.
Cleistanthus collinus.
Dalbergia latifolia.
Dipterocarpus macrocarpus.
Dysoxylum malabaricum.
Evodia lunur-ankenda (*Evodia roxburghiana*).
Juglans regia.
Lagerstrœmia speciosa (*Lagerstrœmia flosreginæ*).
Michelia champaca.
Morus alba.
Picea smithiana (*Picea morinda*).
Prosopis juliflora.
Pterocarpus marsupium.
Schima wallichii.
Terminalia myriocarpa.
Vateria indica.
Xylia xylocarpa.

PRIORITY II

Acer spp.
Albizzia lebbeck.
Albizzia procera.
Alnus nitida.
Azadirachta indica.
Calophyllum elatum (*Calophyllum tomentosum*).
Chukrasia tabularis.
Cullenia excelsa.
Cupressus torulosa.
Palaquium ellipticum (*Dichopsis elliptica*).
Syizygium cumini (*Eugenia jambolana*).
Fraxinus floribunda.
Grewia tiliæfolia.
Hardwickia binata.
Hymenodictyon excelsum.
Kydia calycina.
Lagerstrœmia lanceolata.
Lannea grandis.
Lophopetalum wightianum.
Machilus macrantha.
Mangifera indica.
Mesua ferrea.
Michelia kingii.
Mitragyna parvifolia.
Ougeinia dalbergioides.
Phœbe goalparensis.
Prunus cornuta (*Prunus padus*).
Quercus floribunda (*Quercus dilatata*).
Quercus incana.
Quercus semecarpifolia.
Salix alba.
Sterculia urens.
Michelia baillonii (*Talauma phellocarpa*).
Terminalia paniculata.
Terminalia tomentosa.
Tetrameles nudiflora.

and (ii) state silviculturists should lay out tree increment plots for the above species in order to collect reliable information regarding their diameter and height increments.

Whereas

suggestions have been made at this Conference for undertaking ecological studies of important timber species and ecological surveys as aid to afforestation and soil conservation work ;

this Conference recommends that the programme of work for the Ecologist should include :—

(i) basic studies of environmental factors and their relationship to ground forest communities and growth of tree seedlings in forests near Dehra Dun ;

(ii) successional studies of important forest communities in sal and conifer forests ; and

(iii) ecological surveys in the Rajasthan and Saurashtra deserts as preliminary to the selection of species and sites for afforestation work.

B. PROBLEMS OF AFFORESTATION

Whereas

(*a*) the afforestation of waste lands has assumed great importance in recent years as a measure of extending the forest areas, creation of farm forests and arresting soil erosion ;

(*b*) the restoration of plant cover in strategic areas in arid tracts, especially in Rajasthan and Saurashtra, has become a matter of national importance in order to arrest the spread of aridity and for preventing sands from being lifted and blown on to fertile tracts ;

(*c*) sufficient information as regards the technique of raising trees in such tracts is not available in this country ;

(*d*) such afforestation work in lands outside reserved forests is fraught with very considerable difficulties on account of the heavy incidence of grazing and browsing and other biotic factors and the extremely adverse conditions for plant growth ; and

(*e*) it is essential in such difficult work to pool the experience of the States in India as well as of other countries and to organize intensive research in this work ;

this Conference recommends that

(i) the Central Silviculturist should compile information available in the States in collaboration with the state silviculturists and publish, at an early date, the material in a suitable form ;

(ii) state silviculturists should undertake research in all problems connected with the afforestation of such areas ; and

(iii) a desert afforestation research station should be set up under the auspices of the Forest Research Institute at a suitable place in Rajasthan for investigating techniques and species for the afforestation of arid tracts.

C. SOIL CONSERVATION AND AMELIORATION OF CLIMATIC CONDITIONS

Whereas

(*a*) faulty land management continues to be a serious hindrance to the prosperity of the country, and the success of Grow More Food plans ;

(*b*) land laws, land regulations and agricultural practices in the States are not usually in conformity with sound soil conservation technique ;

(*c*) multi-purpose river valley development projects and schemes for the construction of high dams involve the application of sound land management technique in the upper catchment areas of the streams and rivers concerned to reduce soil losses, and their silt load, and thereby to increase the useful life of the dams ;

(*d*) the spread of the Rajasthan desert calls for immediate preventive and remedial measures ;

(*e*) excessive felling of trees leading often to denudation of steep slopes, and unrestricted grazing and browsing by a large number of uneconomic cattle, sheep and goats constitute some of the basic dangers to proper conservation and land management ; and

(*f*) knowledge of succession and retrogression in soils in a state of active erosion is inadequate ;

this Conference recommends that

(i) land use and land capability survey being a useful preliminary for devising correct soil conservation measures

(*a*) land and water conservation survey be carried out in all States, especially in the catchment areas of all important rivers, with a view to concentrating work in regions immediately needing attention ; and

(*b*) classification of land be undertaken according to the use to which land is being put at present and reclassification made according to the use it should be put to.

(ii) all States should examine their respective land laws and regulations in force with a view to modifying them, so as to bring them into conformity with the principles of sound land management. Special attention may be drawn to the Delhi and Ajmer-Merwara Land Development Act, which from the soil conservation point of view is one of the best so far evolved in India ;

(iii) soil conservation work in the catchment areas of the multi-purpose river valley development projects being of national importance, it should be the basic maxim that in the preparation of the estimates of such projects, the cost of the soil conservation measures should form an integral part of the estimates. Sound land management in such basins will lower the silt load of the rivers and prolong the period of utility of the projects ;

(iv) active co-operation of the people in each region being one of the essential requirements for the success of any soil conservation scheme, States should endeavour to create a forest and soil sense amongst the people ;

(v) forest departments should carry out ecological survey for working out the ecological succession, so as to facilitate the choice of species including fodder grass, both indigenous and exotic, appropriate to each stage of succession, to be introduced and propagated under the soil conservation schemes ; and

(vi) research should be undertaken at the Forest Research Institute for the study of forest influences in order to fill the gaps in our knowledge of the reactions of the forest on the physical, climatic and edaphic factors of the locality in the tropics.

D. TREE CULTURE IN LANDS OUTSIDE FORESTS

Whereas

(*a*) there has been a great reduction in the number of trees standing in lands outside forests as a result of indiscriminate fellings, clearings and improper land use ;

(*b*) this abuse has not only impaired the aesthetic value and utility of the land, but has also caused deterioration in the prevailing local, physical and climatic conditions and has caused acute shortage of timber, fuel and fodder ; and

(*c*) it is necessary to reverse this tendency by restoring the lost reverence of the people for trees through an intensive programme of tree planting on all available lands and so to effect land transformation ;

this Conference recommends that

an active programme of planting trees along road-sides, railway tracks, canals, embankments, compounds of public buildings, military camping grounds, tank bunds, field bunds should be sponsored by forest department in collaboration with other departments by providing planting stock, information and technical guidance. In this work full advantage should be taken of the enthusiasm and emotional appeal generated by the *Vana Mahotsava* movement to secure the introduction of tree growth in private lands.

E. FOREST GENETICS AND SEED CONTROL

Whereas

(*a*) the vital role which genetics can play in forestry practice is now well recognized ; and

(*b*) it may be possible through genetical studies to evolve disease resistant strains of valuable species as well as to improve the technical and other qualities of important species :

this Conference recommends that

(i) the Central Silviculturist should as soon as facilities become available :

(*a*) start genetical studies in evolving desirable strains of important species, in collaboration with the state silviculturists ;

(*b*) initiate experiments in starting seed orchards with desirable strains of forest tree species ; and

(*c*) conduct cytological studies of important species ; and

(ii) steps should be taken to create a post of forest geneticist with adequate staff and equipment in the Silviculture Branch for the prosecution of this work.

F. NATURAL AND ARTIFICIAL REGENERATION

(1) *Evergreen forests*

Whereas

(*a*) the general principles underlying the regeneration of evergreen and semi-evergreen forests in India (and adjacent countries) are fairly well understood ; and

(*b*) techniques conforming to such principles seldom fail to obtain regeneration or. alternatively, to establish the regeneration already existing on the ground ;

this Conference is firmly of the opinion that

(i) any radical departure from the method of "Selection" fellings, which experience has shown to be the correct method, can only be justified in very special circumstances ; and

(ii) such departure should be made with the full realization of its implications, that is, the grave risk of disturbing the delicate ecological balance which exists in evergreen forests and of causing permanent and even irreversible changes in the floristic composition of the forest to the detriment of long term interests.

(2) *Teak*

Whereas

(*a*) the joint co-operative tour recommended in item 5 of the VI Silvicultural Conference (1945) has regrettably not materialized ;

(*b*) the resolution of the VII Silvicultural Conference (1946) under item No. 1 (g–3) has also not been given effect to ;

this Conference recommends that joint co-operative tours of the Central Silviculturist and State representatives including state silviculturists be undertaken with the least possible delay in order to study the problems of regeneration, management and ecology of teak in various parts of the Union. and the whole subject be written up at the end of the tour, by the Central Silviculturist.

Whereas

(*a*) teak is not confined to India, but occurs over an extensive region, and there is much to learn from and profit by the work done in other teak-bearing countries such as Burma, Indonesia, Thailand and Laos ; and

(*b*) the importance of direct field observations and local study and discussion of common problems and exchange of views cannot be over emphasized ;

this Conference recommends that

the Government of India should take steps to :

(i) move the Forestry and Forest Products Commission for Asia and the Pacific established by the Food and Agriculture Organization of the United Nations to convene a working party on an international basis for the study of the silviculture and management of teak ;

(ii) make use of the Fellowship facilities provided under the Expanded Technical Assistance Programme of the Food and Agriculture Organization of the United Nations to arrange a joint tour of the States representatives including silviculturists of States interested in the management of teak in the adjoining teak producing countries of Asia.

(3) *Sal*

Whereas

(*a*) natural reproduction of sal is absent or deficient over large areas of important sal forests in India ; and

(*b*) the problems of obtaining and establishing natural sal regeneration to an adequate extent remain unsolved :

this Conference recommends that

(i) more attention should be paid to management systems with non-concentrated regeneration with a view to evolving suitable scientific systems for proper management of sal forests in which adeqate natural regeneration cannot at present be obtained and established ;

(ii) the problem of natural regeneration by seed under a shelterwood should be studied in greater detail, involving the manipulation and control of soil and seed, in addition to the usual treatments of burning, fencing, and control of herbs, shrubs, and the canopy at various levels ;

(iii) as the uniform system has failed to obtain and establish *de novo* regeneration over large tracts as in the Uttar Pradesh, less rigid systems of obtaining regeneration under a shelterwood should be investigated in accordance with the character and needs of the locality ;

(iv) concurrent studies should be undertaken to gather basic data for important communities and sub-types from an ecological point of view. Such studies should cover both laboratory and field investigations for a proper understanding of the interactions of the locality factors, and their amelioration to achieve the ends in view ;

(v) with regard to the management of depleted stands, especially private forests near heavily settled tracts, further research should be undertaken to evolve suitable forms of coppice or coppice-with-standards systems, which are well suited to produce the various classes of material which the local agricultural population requires ; and

(vi) in general the problem of sal natural regeneration, whether by seed or coppice, concentrated or non-concentrated, should be tackled on a broader front, and with less rigidity, with emphasis on the quantitative evaluation of factors.

(4) *Taungya*

Whereas

(*a*) the *taungya* method of artificial regeneration is showing signs of strain and its results are now not as satisfactory as they were before ; and

(*b*) the *taungya* method may at any time become impracticable, partially or totally, and have to be replaced by other methods of artificial regeneration ;

this Conference recommends that

(i) attempts should be made, up to the limit of the number of satisfactory cultivators available, to safeguard the continuity of the *taungya* method by providing inducements and increased facilities ; and

(ii) in places where *taungya* can no longer be depended on, alternative methods should be standardized so that the process of regeneration is not hindered or stopped. This may call for departmental operations, possibly mechanized, and competitive wage levels to ensure an adequate supply of labour.

G. MORTALITY IN FOREST SPECIES

Whereas

(*a*) information relating to the incidence of diseases and pests of trees and crops of our forests is essential for forest management ;

(*b*) a number of forest pathological and entomological problems await study and solution ;

(*c*) remedial measures are, in general, of limited application in normal forestry practice ;

(*d*) information on the above subjects is meagre ;

this Conference recommends that

(i) a survey of diseases and pests of all important forest species should be done periodically ;

(ii) statistics relating to the annual losses caused by the various diseases and pests should be collected ; and

(iii) attention should be concentrated on evolving preventive measures, generally based on modifications of silvicultural practices, with due regard to the factors of the locality.

Whereas it appears that the following are the major pathological and entomological problems facing forest departments, namely

(*a*) mortality of casuarina in Orissa, Madras, Mysore and Bombay ;

(*b*) mortality of spruce, fir and deodar in Uttar Pradesh, Himachal Pradesh, Punjab and Kashmir ;

(*c*) skeletonization of teak in Madras, Bombay and Madhya Pradesh ;

(*d*) loranthus attack on *Gmelina arborea* and sal in Bengal and Assam and on teak in Bombay and attack of *Arceuthobium minutissimum* on blue pine at high levels ;

(*e*) mortality of sissoo in northern India ;

(*f*) mortality of babul in Bombay ;

(*g*) rat damage to sal seedlings in Assam ;

this Conference recommends that the Forest Research Institute, in collaboration with the States concerned, should take up the study of these problems during the next quinquennium with a view to evolving suitable practical preventive and remedial measures.

Whereas study and control of pests of forest tree seeds is very important ;
this Conference recommends that all State forest departments should furnish prompt information of outbreaks of seed infection to the Forest Research Institute, noting whether such outbreaks are of frequent occurrence and economic importance.

II. FOREST SURVEYS

B. SURVEY OF RESOURCES

(1) *Application of statistical methods and sampling methods in enumerations, etc.*

Whereas

(*a*) sufficiently accurate surveys of growing stock, regeneration, etc., are essential for the proper management of forests ;

(*b*) it is necessary to keep the cost of collection of data within reasonable limits consistent with the accuracy aimed at ;

(*c*) such surveys have to be carried out in various types of forests and for different purposes ;

(*d*) statistical research should be undertaken to devise appropriate sampling methods ;
this Conference recommends that

(i) increasing use of proper sampling techniques should be made in the collection of data ;

(ii) the methods and intensity of sampling suitable for different types of areas and purposes should be experimentally determined for large scale application ;

(iii) in extensive plains forests existing data indicate that stratified random or systematic strip surveys or line-plot surveys should be suitable for assessing the growing stock and regeneration. The locality factors will influence the choice of the method ;

(iv) in high level hill forests where such surveys are difficult and costly to carry out, full use should be made of existing compartments or sub-compartments, if small enough, as sampling units, otherwise temporary topographical sampling units should be formed for stratified random sampling. The actual method and intensity of the survey should be based on experimental results and should take the locality factors into consideration.

(v) for plains forests line-plot surveys seem to be preferable to strip sampling. Their application should be further investigated ;

(vi) strip or line-plot methods appear to be best adapted for sampling of regeneration both on the hills and in the plains ;

(vii) greater attention should be paid to the application of suitable sampling techniques to estimate the outturn of different classes of forest products ;

(viii) all States be invited to consult the Statistician, Forest Research Institute, Dehra Dun, and make use of his services before undertaking sampling enumeration on any large scale and be requested to furnish the Statistician with the data collected in such enumeration so as to enable him to devise improved sampling methods in the various types of forests in India ; and

(ix) the need for providing the statistical branch with adequate staff should be kept in mind.

(2) *Statistics relating to minor forest products*

Whereas

(*a*) minor forest products, occurring in Indian forests, constitute roughly 30 per cent of the total forest wealth of the country ;

(*b*) they play an important role in the economy of the nation, both rural and industrial, besides earning foreign exchange worth about 18 crores of rupees annually :

(*c*) little or no reliable data are available with regard to the quantities and values of most even of the important minor forest products annually removed from forests, and consequently the better utilization of these resources is rendered difficult ; and

(*d*) there is considerable scope for increasing the already large income from minor forest products through the collection of accurate data ;

this Conference recommends that

(i) immediate steps be taken to collect data on important minor forest products, according to proformas 1 and 2 (enclosed herewith) prepared by the Forest Research Institute ;

(ii) the provisional list of important minor forest products which has been drawn up on an all-India basis may be enlarged if any State considers that the data on some minor forest products not included in the list, should also be collected separately ;

(iii) the data so collected be sent to the Publicity and Liaison Officer of the Forest Research Institute in triplicate (one copy for the Publicity and Liaison Officer, one for the Minor Forest Products Branch of the Forest Research Institute and one for the Directorate of Economics and Statistics, Ministry of Food and Agriculture, Government of India); and

(iv) the Directorate of Economics and Statistics be requested to collect the necessary data from other civil departments, corporate bodies, private firms, etc., according to these proformas and consolidate and publish the data annually.

PROFORMA No. 1

Outturn of Minor Forest Produce

All Forests—During the year..........

Name of Commodity	Forest Departments				Other Civil Departments				Corporate bodies				Private bodies				TOTAL		
	Quantity collected*	Value			Quantity collected*	Value			Quantity collected*	Value			Quantity collected*	Value			Quantity collected*	Value	
		Net Revenue†	Wholesale market rate‡	Wholesale market value		Net Revenue†	Wholesale market rate‡	Wholesale market value		Net Revenue†	Wholesale market rate‡	Wholesale market value		Net Revenue†	Wholesale market rate‡	Wholesale market value		Net Revenue†	Wholesale market value
As per list below :—																			

* Quantity should be given in Railway maunds of 82 2/7 lb.
† Net revenue means the lease money realized or, in case of departmental collection, the total revenue minus the collection charges.
‡ Wholesale market rate should be given in Rupees for a Railway maunds of 82 2/7 lb.

List of raw materials or such finished products for which Forest Departments may be able to supply figures.

I.—DRUGS

1. Aconite (*Aconitum* spp., usually collectively known as Nepal aconite).
2. Aconite (*Aconitum chasmanthum* Stapf ex Holmes).
3. Atis or Patis (*A. heterophyllum* Wall.).
4. Asafœtida (re-exported) (*Ferula fœtida* Regel, and other sp.).
5. Artemisia (*Artemisia brevifolia* Wall.).
6. Bengal kino (*Butea monosperma* Kuntze ; syn. *B. frondosa* Kœn. *ex* Roxb.).
7. Banafsha (*Viola odorata* Linn.).
8. Banafsha substitutes (*Viola* sp.).
9. Belladonna Indian (*Atropa acuminata* Royle).
10. Costus (*Saussurea lappa* Clarke).
11. Cinchona bark (*Cinchona* spp.).
12. Colocynth (*Citrullus colocynthis* Schrad.).
13. Croton oil (*Croton tiglium* Linn.).
14. Chirata (*Swertia chirata* Ham.).
15. Chirata substitute (*S. angustifolia* Ham.).
16. Eucalyptus oil (*Eucalyptus globulus* Labill.).
17. Ephedra (*Ephedra* spp.).
18. Galangal (*Alpinia* spp.).
19. Gaultheria (*Gaultheria fragrantissima* Wall.).
20. Henbane (*Hyoscyamus niger* Linn.).
21. Kurchi bark (*Holarrhœna antidysenterica* Wall.).
22. Long pepper (*Piper longum* Linn.).
23. Nux-vomica (*Strychnos nux-vomica* Linn.).
24. Neem seed (*Azadirachta indica* A. Juss.).
25. Podophyllum (*Podophyllum hexandrum* Royle ; syn. *P. emodi* Wall.).
26. Purging fistula fruits (*Cassia fistula* Linn.).
27. Rhubarb (*Rheum emodi* Wall.).
28. Senna (*Cassia angustifolia* Vahl and *C. acutifolia* Delile).
29. Sarpagandh roots (*Rauwolfia serpentina* Benth. *ex* Kurz).
30. Taraxacum (*Taraxacum officinale* Weber).
31. Valerian (*Valeriana wallichii* DC.).
32. Other sorts of vegetable drugs and medicines (names should be given).

(*contd.*)

List of raw materials or such finished products for which Forest Departments may be able to supply figures—(contd.)

II.—SPICES

1. Cardamoms, Lesser (*Elettaria cardamomum* Maton).
2. Cardamoms, Greater (*Amomum subulatum* Roxb.).
3. Nutmeg (*Myristica fragrans* Houtt.).
4. Pepper (*Piper nigrum* Linn.).
5. Tejpat (*Cinnamomum tamala* Nees).
6. Other species (names to be mentioned).

III.—GUMS AND RESINS

1. Boswellia resin or Olibanum or frankincense (*Boswellia serrata* Roxb.).
2. Bhilawa (*Semecarpus anacardium* Linn. f. & *S. travancoricus* Bedd.).
3. Bdellium Indian (*Commiphora mukul* Engl., syn. *Balsamodendron mukul* Hook. *ex* Stokes).
4. Dammar Black (*Canarium strictum* Roxb.).
5. Dammar sal (*Shorea robusta* Gærtn. *f.*).
6. Dammar white (*Vateria indica* Linn.).
7. Gurjun balsam (*Dipterocarpus turbinatus* Gærtn. *f.*).
8. Gum arabic (*Acacia senegal* Willd.).
9. Gum babul (*A. arabica* Willd.).
10. Gum ghatti (*Anogeissus latifolia* Wall.).
11. Gum karaya (*Sterculia urens* Roxb.).
12. Gum kino (*Pterocarpus marsupium* Roxb.).
13. Pine resin (*Pinus longifolia* Roxb.).
14. Other sorts (names to be mentioned).

IV.—LAC

V.—DYEING AND TANNING SUBSTANCES

1. Bark avaram (*Cassia auriculata* Linn.).
2. Bark sonari (*Cassia fistula* Linn.).
3. Bark babul (*Acacia arabica* Willd.).
4. Bark, Black Wattle (*Acacia mollissima* Willd.).
5. Bark, Green Wattle (*Acacia decurrens* Willd.).
6. Barks others for tanning (names to be mentioned).
7. Cutch (*Acacia catechu* Willd.).
8. Katha (*Acacia catechu* Willd.).
9. Kamala powder (*Mallotus philippinensis* Muell. Arg.).
10. Myrobalans, Emblic (*Emblica officinalis* Gærtn. ; syn. *Phyllanthus emblica* Linn.).
11. Myrobalans, Chebulic (*Terminalia chebula* Retz.).
12. Pods, Babul (*Acacia arabica* Willd.).
13. Pods, Divi-divi (*Cæsalpinia coriaria* Willd.).
14. Other dyeing and tanning substances (names to be given).

VI.—FIBRES

1. Bhabar grass (*Eulaliopsis binata* Hubbard ; syn. *Ischæmum angustifolium* Hack.).
2. Munj (*Saccharum munja* Roxb.).
3. Palmyra (*Borassus flabellifer* Linn.).
4. Rajmahal hemp (*Marsdenia tenacissima* W. & A.).
5. Fibres for brushes and brooms.
6. Other fibres (names to be mentioned).

VII.—FLOSS

1. Aak (*Calatropis* spp.).
2. Kapok, Indian (*Bombax malabaricum* DC.).
3. Other flosses (names to be mentioned).

VIII.—CANES AND RATTANS (*Calamus* spp.)

IX.—MATS AND MATTING (except Coir and rubber)

X.—ESSENTIAL OILS OR RAW MATERIALS THEREOF

1. Cinnamon leaf oil (*Cinnamomum zeylanicum* Breyn.).
2. Cinnamon bark oil (*Cinnamomum zeylanicum* Breyn.).
3. Citronella oil (*Cymbopogon nardus* Rendle).
4. Ginger grass oil (*Cymbopogon martini* Stapf, var. *sofia*).
5. Keora (*Pandanus tectorius* Soland. ex. Balf. f. ; syn. *P. odoratissimus* Linn. *f.*).
6. Lemon grass oil, East Indian (*Cymbopogon flexuosus* Stapf).
7. Lemon grass oil, West Indian type (*Cymbopogon citratus* Stapf).
8. Musk.
9. Palmarosa oil (*Cymbopogon martini* Stapf, var. *motia*).
10. Sandalwood (*Santalum album* Linn.).
11. Turpentine (*Pinus longifolia* Roxb.).
12. Vetiver oil (*Vetiveria zizanioides* Nash).
13. Other essential oils (names to be mentioned).

XI.—VEGETABLE OILS (NON-ESSENTIAL) AND OIL SEEDS

1. Cashew nut shell oil (*Anacardium occidentale* Linn.).
2. Kusum seeds (*Schleichera oleosa* Merr. ; syn. *S. trijuga* Willd.).
3. Kamala seeds (*Mallotus philippinensis* Muell. Arg.).
4. Mohua (*Madhuca* spp. ; syn. *Bassia* spp.).
5. Phulwa (*Madhuca butyracea* Macbride ; syn. *Bassia butyracea* Roxb.).
6. Pinnay (*Calophyllum inophyllum* Linn.).
7. Pungam (*Pongamia pinnata* Merr. ; syn. *P. glabra* Vent.).
8. Other vegetable oils and oil seeds (names to be mentioned).

(*contd.*)

List of raw materials or such finished products for which Forest Departments may be able to supply figures—(concld.)

XII.—FRUITS AND VEGETABLES

1. Ber (*Zizyphus jujuba* Lam.).
2. Chilgoza (*Pinus gerardiana* Wall.).
3. Cashew nut (*Anacardium occidentale* Linn.).
4. Sitaphal (*Anona* spp.).
5. Sati food (*Curcuma* sp.).
6. Tamarind (*Tamarindus indica* Linn.).
7. Walnut (*Juglans regia* Linn.).
8. Yams (*Dioscorea* spp.).
9. Other fruits and vegetables (names to be mentioned).

XIII.—WAXES (EXCLUDING PARAFFIN)

Beeswax.

XIV.—IVORY UNMANUFACTURED

XV.—HONEY

XVI.—MISCELLANEOUS

1. Bamboos.
2. Bristles.
3. Bidi leaves (*Diospyros melanoxylon* Roxb.).
4. Button seeds (*Corypha umbraculifera* Linn.).
5. Charcoal.
6. Entada seeds (*Entada pursætha* DC. ; syn. *E. scandens* Benth.).
7. Fodder plants.
8. Horns and skins.
9. Leaves for plates and cups (*Bauhinia* spp., *Butea monosperma* Kuntze, etc.).
10. Pyrethrum (*Chrysanthemum cinerariifolium* Vis.).
11. Rubber, raw (*Hevea braziliensis* Muell. Arg. & others).
12. Soap nuts (*Sapindus* spp.).
13. Shikakai (*Acacia concinna* DC.).
14. Sola pith (*Aeschynomene aspera* Linn.).
15. Stones and minerals quarried in forests.
16. Thatching grass.
17. Thorns.
18. Willow pollards.
19. Others.

PROFORMA NO. 2

Manufactures from Indian minor forest products

Name of product	Quantity* of raw material used	Value of raw material used	Quantity* of finished product	Value of finished product
As per list below :—				

* Quantity should be given in lb.

List of important finished products for which figures will be available from Department of Industries or private firms and Government Departments

1. Belladonna preparations (*Atropa acuminata* Royle).
2. Quinine salts (*Cinchona* spp.).
3. Ephedrine (*Ephedra* spp.).
4. Strychnine (*Strychnos nux-vomica* Linn.).
5. Santonin (*Artemisia brevifolia* Wall.).
6. Podophyllum resin (*Podophyllum hexandrum* Royle ; syn. *P. emodi* Wall.).
7. Turpentine (*Pinus longifolia* Roxb.).
8. Rosin (*Pinus longifolia* Roxb.).
9. Button lac.
10. Seed lac.
11. Shellac.
12. Stick lac.
13. Other kinds of lacs.
14. Cutch (*Acacia catechu* Willd.).
15. Katha (*Acacia catechu* Willd.).
16. Myrobalan extracts (*Terminalia chebula* Tetz.).
17. Linaloe oil (*Bursera delpechiana* Poiss. ex Engl.).
18. Cinnamon leaf oil (*Cinnamomum zeylanicum* Breyn.).
19. Cinnamon bark oil (*Cinnamomum zeylanicum* Breyn.).
20. Citronella oil (*Cymbopogon nardus* Rendle.).
21. Ginger grass oil (*Cymbopogon martini* Stapf, var. *sofia*).
22. Lemon grass oil (*Cymbopogon flexuosus* Stapf, and *C. citratus* Stapf).
23. Palmarosa oil (*Cymbopogon martini* Stapf, var. *motia*).
24. Sandalwood oil (*Santalum album* Linn.).
25. Vetiver oil (*Vetiveria zizanioides* Nash).
26. Cashew nut shell oil (*Anacardium occidentale* Linn.).
27. Mahua oil (*Madhuca* spp.).
28. Beeswax.
29. Raw rubber (*Hevea braziliensis* Muell. Arg.).
30. Manufactured rubber.
31. Manufactured Ivory.
32. Any other important product manufactured from Indian minor forest product.

(3) *Statistics of outturn*

Whereas

(*a*) the statistics of outturn reported at present, cover only areas under the control of forest departments and it is necessary to extend the coverage by including information in respect of all types of forests whether owned by private individuals, State governments or corporate bodies ;

(*b*) the scope of statistics has to be enlarged by collecting information on a number of additional items for which little or no information is available at present ; and

(*c*) the accuracy and comparability of available forest statistics have to be improved ; this Conference recommends

(i) that the Directorate of Economics and Statistics, Ministry of Food and Agriculture, be requested to circulate its suggestions for improvement of the forest statistics of India to heads of forest departments in the various States ;

(ii) that the Inspector-General of Forests be requested to convene a meeting of heads of forest departments to discuss these suggestions and to evolve a national system of forest statistics comparable in scope and accuracy with the systems of other countries ; and

(iii) that the technical assistance of the Food and Agriculture Organization of the United Nations be sought in the planning and execution of a national forest inventory for the whole of India.

III. FOREST ECONOMICS INCLUDING MANAGEMENT AND POLICY

B. FOREST MANAGEMENT

(1) *Management and improvement of forest grazing and forest fodder*

Whereas

(*a*) several States, in which systematic grazing rules did not exist, have been recently integrated into the Indian Union ;

(*b*) during the last five years, large areas of grazing grounds have been handed over for cultivation under the "grow-more-food" scheme ;

(*c*) cattle population all over India is rapidly on the increase ; and

(*d*) in all future legislative enactments for the management of private or community forests and waste lands, and in all the working plans of State forests, provisions for the limitation of the incidence and for the regulation of the movement of cattle are essential in the interests of forest and soil conservation, animal husbandry and conservation of fodder and grazing resources ; and

(*e*) in all the States of the Union, the improvement of grass lands is a problem which requires immediate attention ;

this Conference recommends that

(i) the attention of all States be drawn to the resolution on Item No. 8, "Pasture and Fodder", passed by the VII Silvicultural Conference, which remains still unimplemented ;

(ii) the incidence of grazing be limited to the carrying capacity of the pasture which should be correctly determined by an agrostologist ;

(iii) utility cattle, both draught and milch, be given preference in admission to the pastures ;

(iv) measures to improve the grazing resources and pasture lands be immediately taken, through the introduction of suitable grasses, legumes and fodder trees in the pastures and by encouragement of hay making and silage ; and

(v) an agrostologist be appointed in each State to work out the details of the carrying capacity of the pasture lands and to evolve the technique of introducing useful indigenous pasture grasses as well as to initiate measures for the improvement of our grass lands.

(2) *Preservation of wild-life, national parks, game sanctuaries, game laws, etc.*

Whereas

(*a*) wild-life is an integral element of our forests and its preservation is admitted on all hands to be an urgent necessity ;

(*b*) in many States which have been integrated into the Indian Union, adequate forest areas have not been set apart for the preservation and perpetuation of the different kinds of wild-life ;

(*c*) in many States shooting rules for regulating shooting in State forests do not exist or where they do exist they are not always adequate ;

this Conference recommends that

(i) suitable forest areas of adequate extent be set apart in each State for the preservation and perpetuation of wild-life ;

(ii) appropriate game rules be framed and brought into force to prevent indiscriminate destruction of wild-life ;

(iii) an All-India committee be set up by the Government of India for co-ordinating the activities of all the States in these respects.

(3) *Management of village forests, community forests, etc.*

Whereas

(*a*) recent statistical data reveal that our forests are considerably understocked ; and

(*b*) the ever increasing demands of the country require that more and more forest products be made available ;

this Conference recommends that the States be requested to consider seriously this question and to take active measures to increase the growing stock in the forest areas with a view to stepping up production.

(4) *Maintenance of standards in the preparation of working plans*

Whereas

(*a*) revision of several working plans is overdue and newly acquired forest areas are in urgent need of either working schemes or working plans ;

(*b*) it is necessary to collect basic data on uniform lines ;

(*c*) only a few States have got working plan manuals detailing procedure for the guidance of the working plan officers and others in the preparation and control of forest working plans ;

(*d*) it is found that several of the States have got no working plan circles ; and

(*e*) it is necessary to have a uniform and correct procedure for ensuring the preparation and control of forest working plans for the whole of the Indian Union ;

this Conference recommends that

(i) a uniform procedure for the preparation and control of working plans and working schemes for the whole of the Indian Union be drawn up and published as a Working Plan Code by the Central Silviculturist ;

(ii) all the major States, which have no separate working plan circles should consider the creation of separate working plan circles ; and

(iii) a suitable advisory and co-ordinating body be organized at the centre to exercise technical scrutiny of major working plans prepared in the States. It may be feasible and convenient for such technical scrutiny to be effected at the stage of the preliminary or reconnaissance report of the working plan.

IV. GENERAL TOPICS

(1) *Ledger classification*

Whereas

(*a*) Howard's system for filing information, which was introduced in the Forest Research Institute and in the other silvicultural research offices of India about 25 years ago, as an improvement on the older system which it replaced, has of late been found to be inadequate in various ways on account of the great increase in the bulk and range of knowledge which has accumulated in recent years ; and

(*b*) the internationally accepted system of filing information associated with the name of Flury, as recently revised, offers more precise and detailed heads of classification, and is, therefore, better suited to the needs of the greatly increased volume of literature which has to be ledgered ;

this Conference recommends that Howard's system be replaced by the Revised (Oxford) System of classification (as approved by the International Union of Forest Research Organizations and the Food and Agriculture Organization of the United Nations) in the Forest Research Institute and in all the silvicultural research offices of India, for all *future* classification of literature.

(2) *Thinnings*

Whereas

(*a*) the existing classification of trees has been observed to be inadequate in certain respects ; and

(*b*) it appears desirable to introduce the concept of "free crowns" in the classification ;

this Conference recommends that thinning technique based on the concept of "free crowns" should be tested as regards practicability and efficiency by the Central Silviculturist in representative new sample plots.

(3) *Forest types*

Whereas

(*a*) Indian Forest Record (New Series), Silviculture, Vol. I, No. 1, entitled "A preliminary survey of the forest types of India and Burma", is in considerable demand both in India and elsewhere ;

(*b*) it is now out of print ;

(*c*) such additional material as has been collected on the subject is not sufficient to warrant a revision of the Record ; and

(*d*) detailed studies of forest types and sub-types are still needed ;

this Conference recommends that

(i) the Indian Forest Record should be reprinted with suitable addenda, as a new edition ;

(ii) working plan officers be requested to classify vegetation in Chapter II of Part I of their working plans according to Champion's types and sub-types. When any vegetational community is encountered which does not fit into the above classification, the working plan officer should describe the vegetation in detail so as to facilitate the recognition of a new sub-type ;

(iii) this part of Chapter II should be scrutinized by the state silviculturist, especially in respect of any new sub-type ;

(iv) from each working plan received by the Central Silviculturist, necessary data for the revision of the Indian Forest Record referred to above should be collected ; and

(v) the technique of describing vegetation for classifying the main and sub-types may be specially stressed in the lectures on ecology in the Indian Forest College.

(4) *Publications*

Whereas

(*a*) technical publications are permanent records ;

(*b*) publication of research material and working plans should take place at the earliest possible date after their preparation ;

(*c*) such technical publications are in considerable demand, and are distributed throughout India and in foreign countries ;

(*d*) the printing and get-up of the publications should be of a high standard so as to be on a par with other international scientific publications ;

(*e*) the results of researches in progressive countries are published and distributed promptly ;

(*f*) the get-up and the printing of our technical publications are often below the standard required for such publications ;

(*g*) the Survey of India press in Dehra Dun already undertakes the printing of certain forest publications in an entirely satisfactory manner ;

this Conference recommends that

(i) high priority should be given by the Government of India and the State governments to the printing of technical forest publications and working plans ;

(ii) the attention of the Government of India and State governments should be drawn to the fact that there is at present inordinate delay in the printing of such publications, with the result that much of their value is lost ;

(iii) there is a genuine need for a central government press located at Dehra Dun, where forest publications of all States can be printed promptly and to the standard required ;

(iv) it would help all State forest departments to get their publications printed at such a central press ;

(v) the Government of India should set up such a central press or, alternatively, expand the existing Survey of India press ; and

(vi) the various State governments should be approached to contribute towards bearing the cost involved, both by a capital grant and by recurring annual contributions.

Whereas

(*a*) it is important to state silviculturists, that interim results of research and experiments carried out by the Forest Research Institute, Dehra Dun, and the States should be published as quickly as possible ; and

(*b*) the information contained in the ledger files of the Central Silviculturist at the Forest Research Institute is not easily available, especially in a summarized form, to state silviculturists ;

this Conference recommends that

(i) important interim results of research and experiments, should be issued (mimeographed if convenient) as leaflets, as early as possible, by the Central Silviculturist or the state silviculturists concerned ;

(ii) the ledger files of the Central Silviculturist should be summarized as far as possible and, published in the form of monographs, taking the specific files first and the general files subsequently.

Whereas

(*a*) delegates from certain States have expressed their desire for a Forest Pocket Book to cover their requirements ;

(*b*) with some additions and modifications Howard's Forest Pocket Book, now under revision, could be made suitable for all States ;

this Conference recommends that the State Silviculturist, Uttar Pradesh, should function as the general editor of the revised edition of Howard's Forest Pocket Book, and that other silviculturists should correspond directly with him in order to include in the revised publication such matters, not now included, as are of particular or general interest to States other than Uttar Pradesh.

(5) *Publication of the proceedings of the VIII Silvicultural Conference*

This Conference resolves that the Secretary (Central Silviculturist) be authorized (i) to edit the Conference proceedings and papers so as to fit them for publication in a suitable form ; (ii) to include in the published proceedings papers which were received late.

The Conference further resolves that the President, Forest Research Institute and Colleges, be authorized to decide at his discretion which of the papers submitted to the Conference should be printed in the final report, and which of them may be published in the *Indian Forester*.

(6) *Date of the next (IX) Silvicultural Conference*

This Conference recommends that the next (IX) Silvicultural Conference be held at Dehra Dun in 1956.

INDIGENOUS CELLULOSIC RAW MATERIALS FOR THE PRODUCTION OF PULP, PAPER AND BOARD

PART VII.—WRITING AND PRINTING PAPERS FROM *PHRAGMITES KARKA*, TRIN.

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SUMMARY

Laboratory experiments on the production of chemical pulps by the soda and sulphate processes from *Phragmites karka*, Trin. (*nal*) are described. The results of pilot plant experiments on the production of chemical pulps and writing and printing papers are included. Since this species of grass grows in habitats where another similar species *Arundo donax*, Linn., is found, a digestion on a pilot plant scale of a mixture of these two grasses was carried out with satisfactory results. Samples of paper made from *Phragmites karka* and from the pulp obtained by digesting the mixture of this species and *Arundo donax* are inserted in this bulletin. The pulps from *Phragmites karka* are short-fibred and hence the admixture of these pulps with long-fibred pulps such as those of sabai grass (*Eulaliopsis binata*) or bamboo is essential for the successful use of this reed for the production of paper on a commercial paper machine. It is reported that this species is found in large quantities in Assam. Since transportation of this reed-like grass to places outside Assam at an economic price is not possible, attention must be directed to the establishment of a paper mill in Assam utilizing this species. Bamboo is also available in Assam for the production of chemical pulp for admixing with the short-fibred pulp of *Phragmites karka* for the manufacture of paper.

INTRODUCTION

Phragmites karka, Trin. (*nal*), belongs to the family Gramineæ. It is a reed-like perennial grass with a creeping rhizome. The botanical description of this species is given in an earlier publication[1]. It grows along river banks and in marshy places. It is found in large quantities in Assam. This grass also occurs in Punjab, Uttar Pradesh, Bengal, Madhya Pradesh, Bombay and Madras. It is also found in Burma. This grass ascends to a height of 3,000 feet. The stems are hollow and are made into shepherd's pipes. As this grass grows abundantly in Assam, especially in Lakhimpur including North Lakhimpur, Sibsagar, Darrang, Goalpara East, and Dhansiri Valley Divisions, the Senior Conservator of Forests, Assam, requested this Institute to test this species for its suitability for the production of pulps for writing and printing papers. An investigation on this species was, therefore, undertaken in this Branch. The results of this investigation are described in this bulletin.

THE RAW MATERIAL

The reeds (3 tons) used for this investigation were supplied by the Divisional Forest Officer, Saharanpur Division (U.P.). The moisture content of the reeds as received was about 8 per cent. The stems of the reeds varied from 10 feet to 12 feet in length; the diameter

was about 0·4 inch. About 6–7 reeds weighed 1 lb. The reeds were greenish-yellow to yellowish-brown in colour. Almost all the leaves had fallen off from the stems but the flowers were present. The reeds with the flowers were crushed between the rollers of the factory crusher and were cut into lengths of about 1 inch on the grass chopper. The chopped material was sieved on the factory sieves to remove the fines which were rejected. The chopped and sieved material was used for the investigation.

PROXIMATE ANALYSIS

The reeds were analysed by the methods used at the Forest Products Laboratory, Madison (U.S.A.) except for the estimation of pentosans where TAPPI standard T 223m-48 was employed. The results of the proximate analysis are given in Table I.

TABLE I

Proximate analysis of Phragmites karka

		% on the oven-dry basis except moisture
1.	Moisture	7·67
2.	Ash	3·09
3.	Cold water solubility ..	0·68
4.	Hot water solubility ..	3·56
5.	1% NaOH solubility ..	26·57
6.	10% KOH solubility ..	43·90
7.	Ether solubility	0·11
8.	Alcohol-benzene solubility ..	2·91
9.	Pentosans	22·49
10.	Lignin	25·70
11.	Cellulose (Cross and Bevan)..	55·23

From the results it is evident that the cellulose content of this species is sufficiently high for its utilization for the manufacture of paper. The lignin content is nearly the same as that of bamboos used in the paper industry.

FIBRE DIMENSIONS

The measurements of the length and diameter of fibres of the chemical pulps produced from this species by the sulphate process using 24% of chemicals (on the oven-dry weight of the raw material) in a concentration of 40 g./litre at 153°C. for 6 hours were carried out by the usual procedures followed in this laboratory. The fibre length varied from 0·50 to 3·20 mm. with an average of 1·20 mm. The average fibre diameter was 0·0116 mm., the minimum and maximum values being 0·0066 mm. and 0·0198 mm. respectively. The ratio of the average fibre length to diameter was 103 : 1. This value is higher than in the case of pulps from hardwoods. The pulps are short-fibred.

PRODUCTION OF PULP

A number of digestions were carried out on a laboratory scale by the soda and sulphate processes. In each digestion 200 g. (on the oven-dry basis) of the raw material were used. In the soda process caustic soda was used for the digestion. In the sulphate process a mixture

of caustic soda and sodium sulphide in the ratio of 2 : 1 was used. The digestions were carried out in a vertical stationary mild steel digester of 3-litre capacity.

After the digestion was completed, the pulp was washed free from alkali and bleached with a solution of bleaching powder by the two-stage method using an intermediate alkali wash. The first stage of bleaching was carried out at 35°C. with about 75% of the total bleaching powder required for the full bleach. The partially bleached pulp was washed and treated with 2% caustic soda (on the oven-dry weight of the pulp) at 70°C. for one hour. After washing it free from alkali the pulp was bleached finally with the remaining quantity of the bleaching powder. The consistency of the pulp during bleaching was 5%. The bleached pulp was washed well and beaten in the Lampen Mill and used for making standard sheets on the sheet-making machine recommended in the Second Report of the Pulp Evaluation Committee to the Technical Section of the Paper Makers' Association of Great Britain and Ireland. The pulp sheets were conditioned at 65% R.H. and 80°F. and tested for their strength properties.

The conditions of various digestions by the soda process, the pulp yields and the strength properties of the standard pulp sheets are given in Table II and similar data for the sulphate digestions are given in Table III.

PILOT PLANT TRIALS

In order to confirm the results obtained on the laboratory scale, pilot plant experiments were carried out. The chopped and sieved material (700 lb. on oven-dry basis) was cooked in a vertical mild steel digester of about 100 cu. ft. capacity. The cooking liquor was circulated throughout the digestion through an outside tubular heater connected to the digester. The cooked material was blown into the blow-pit and transferred to a potcher of about 350 lb. capacity in which it was washed and bleached. The bleaching was carried out by the two-stage method described earlier. The pulp was beaten in a beater of about 350 lb. capacity. The requisite quantities of rosin size, alum and China clay were added and the stock was used for making writing and printing papers on the Fourdrinier paper machine described in an earlier publication[2]. When the digestion was carried out by soda process using 20% of caustic soda on the oven-dry basis of the raw material in a concentration of 40 g./litre for 6 hours at 162°C. for the first 4 hours and 153°C. for the remaining period, the pulp was found to be undercooked and many shives were present. Hence, in subsequent digestions 22% of chemicals on the basis of the oven-dry material was used. The conditions of digestions and the pulp yields are recorded in Table IV and the strength properties of papers made on the pilot plant are recorded in Table V. A sample of writing paper made from *Phragmites karka* by the sulphate process is inserted at the end of this bulletin.

DIGESTION OF A MIXTURE OF PHRAGMITES KARKA AND ARUNDO DONAX

An investigation carried out in this Branch has shown that *Arundo donax,* Linn. (*narkul*), is a suitable raw material for the production of paper[1]. *Arundo donax* is a reed-like perennial grass and is often confused in the field with *Phragmites karka* which grows in similar habitats. Hence it was thought desirable to find out whether these two species could be cooked together on a large scale for producing a good, clean pulp. A mixture of equal quantities of grasses of these two species was cooked by the sulphate process and paper was made on the pilot plant in the usual way. The data regarding this pilot plant experiment are given in Serial No. 3, Tables IV and V. A sample of writing paper made from this pulp is inserted at the end of this bulletin.

DISCUSSION

The results recorded in Table II show that well cooked pulps can be prepared from *Phragmites karka* by the soda process by employing suitable conditions of digestion. More than 18% of caustic soda (on the basis of the oven-dry raw material) is required to get well-cooked pulps free from shives. At 20 and 22% of caustic soda for the digestion pulps with slightly better strength properties are obtained at the lower temperature of 153°C. than at 162°C. used for cooking (cf. Serial Nos. 3, 4, 5 and 7, Table II). The bleach consumption by the pulp is least when 22% of caustic soda is used for the digestion under the conditions studied. This bleach consumption is more than in the case of sabai grass (*Eulaliopsis binata*) which is used to the extent of about 22% of the total fibrous raw materials in the Indian paper industry but is only slightly more than that required by bamboo, the other chief raw material for making paper in this country. The yields of the unbleached and bleached pulps are satisfactory. Under the conditions studied the digestion of these reeds with 22% caustic soda at 153–162°C. for 6 hours gives the best pulps.

The results given in Table III show that well-cooked pulps can be prepared from these reeds by the sulphate process also. In this process also more than 18% of chemicals (on the basis of the oven-dry raw material) is required for getting well-cooked pulps free from shives. At a higher percentage of chemicals for the digestion pulps with better strength properties are obtained at a lower temperature of 153°C. for cooking than at 162°C. Bleach consumption by the pulp is slightly higher in the case of the sulphate process than in the case of the soda process. The yields of the unbleached and bleached pulps are satisfactory. The digestion of the reeds by the sulphate process with 22% of chemicals at 153–162°C. for 6 hours gives pulps with satisfactory strength properties although the conditions given in Serial No. 6, Table III give pulps with higher tensile strength and double folds.

The results of the pilot plant experiments given in Tables IV and V confirm that chemical pulps in satisfactory yields suitable for writing and printing papers can be produced from *Phragmites karka* by the soda and sulphate processes. These results also show that good, clean pulps can be produced by cooking a mixture of *Phragmites karka* and *Arundo donax*. For these trials the paper machine of this Branch was worked at its maximum speed of 50 feet per minute.

Since the pulps from *Phragmites karka* are short-fibred it is essential to mix these with long-fibred pulps such as those of sabai grass or bamboo when paper is to be made on a commercial paper machine which is usually run at a speed of about 300 feet per minute.

UTILIZATION FOR PAPER PRODUCTION

According to the information supplied by the Senior Conservator of Forests, Assam, *Phragmites karka* is available in large quantities in the forest divisions of Assam mentioned earlier. The price of this reed in Assam is about Rs. 40–50 per ton. The transportation of this reed to paper factories even in Bengal is not feasible because of very high freight charges. This species can be used economically for the manufacture of paper in Assam only. At present there are no pulp or paper mills in this State. More paper factories will have to be set up in this country in order to be self-sufficient in paper. Regional distribution of the industry is desirable for obvious reasons. It is reported that fuel, lime, water, etc., required for running a paper factory are available in Assam in suitable places. Bamboo is reported to be available in large quantities in that State ; this raw material will be useful for the production of chemical pulp for mixing with *Phragmites karka* pulp. There is, therefore, a *prima facie* case for investigating the possibilities of setting up a paper mill in Assam. It may also be mentioned here that hardwoods such as *Tetrameles nudiflora* are available in Assam in large quantities. An

investigation is in progress in this laboratory on the production of mechanical and chemical pulps from this species of wood.

CONCLUSIONS

1. Chemical pulps suitable for the manufacture of writing and printing papers can be prepared from *Phragmites karka*. Since such pulps are short-fibred, admixture with long-fibred pulps such as those of sabai grass or bamboo is essential for the utilization of this species for the manufacture of paper.

2. *Phragmites karka* and *Arundo donax* grow in similar habitats and are often confused with each other in the field. It has been shown in this investigation that these two species of reeds can be cooked together to produce good and clean pulps.

3. *Phragmites karka* is available in large quantities in Assam. The best way to utilize this species economically is to use it for the manufacture of paper in Assam. Since there are no paper mills in Assam, possibilities of setting up such a factory in that State should be investigated.

REFERENCES

1. Bhat and Virmani, *Indian Forester*, 1951, **77**, No. 6, 365 ; *Indian Forest Leaflet*, No. 123 (1951).
2. Bhat and Man Mohan Singh, *Indian Forester*, 1951, **77**, No. 11, 664; *Indian Forest Bulletin*, No. 153 (1951).

TABLE II.—*Soda digestions of Phragmites karka*

DIGESTION CONDITIONS AND PULP YIELDS

1	2	3	4	5	6	7	8	9
Serial No.	Total alkali as NaOH*	Concentration of alkali as NaOH	Digestion temperature	Digestion period	Alkali consumption as NaOH*	Unbleached pulp yield*	Bleach consumption as standard bleaching powder containing 35% available chlorine*	Bleached pulp yield*
	%	g./litre	°C.	hours	%	%	%	%
1	18	40	153	6	17·2	50·0	8·4	42·7
2	18	40	162	6	17·5	50·0	10·4	41·5
3	20	40	153	6	18·7	48·5	8·5	43·2
4	20	60	162	6	20·0	46·0	9·8	38·4
5	22	60	153	6	20·6	48·6	7·9	40·0
6	22	60	162	4	21·0	43·3	6·7	37·2
7	22	60	162	6	21·1	46·0	7·6	40·0

* The % is expressed on the basis of the raw material (oven-dry).

and strength properties of standard sheets

STRENGTH PROPERTIES OF STANDARD SHEETS CONDITIONED AT 65% R.H. AND 80°F.							
10	11	12	13	14	15	16	17
Freeness of pulp	Basis weight	Breaking length	Stretch	Tear factor (Marx-Elmendorf)	Burst factor (Mullen)	Folding resistance (Schopper)	REMARKS
c.c. (C.S.F.)	g./sq. metre	metres	%			double folds	
310	60·2	7500	5·0	76·0	35·0	330	The pulp was *slightly* under-cooked. The bleached pulp had a yellowish tinge.
260	58·7	7500	4·5	79·0	35·0	370	The pulp was just cooked. The bleached pulp had a yellowish tinge.
330	57·6	6370	4·0	89·0	31·5	180	In Serial Nos. 3–7 the pulps were well-cooked. The bleached pulps had no yellowish tinge.
330	57·7	5500	4·0	72·0	31·2	80	
310	58·0	6500	3·8	76·2	36·1	100	
340	58·4	5700	3·6	70·3	33·4	70	
320	60·8	6000	3·6	70·3	32·1	80	

TABLE III.—*Sulphate digestions of Phragmites karka*

DIGESTION CONDITIONS AND PULP YIELDS

1	2	3	4	5	6	7	8	9
Serial No.	Total chemicals* ($NaOH$: Na_2S = 2 : 1)	Concentration of chemicals	Digestion temperature	Digestion period	Consumption of chemicals*	Unbleached pulp yield*	Bleach consumption as standard bleaching powder containing 35% available chlorine*	Bleached pulp yield*
	%	g./litre	°C.	hours	%	%	%	%
1	18	40	153	6	17·8	50·6	16·5	41·6
2	18	40	162	6	17·8	48·3	12·6	39·2
3	20	40	153	6	19·8	48·3	9·9	38·2
4	22	40	153 for the first 2 hours and 162 for the remaining period	6	21·3	43·3	8·3	41·6
5	22	40	162	6	21·0	42·0	9·7	38·6
6	24	45	153	6	22·8	48·0	8·6	37·3
7	24	45	153 for the first 2 hours and 162 for the remaining period	6	22·6	44·0	8·4	39·0
8	24	45	162	6	23·0	44·0	8·5	37·0

* The % is expressed on the basis of the raw material (oven-dry).

and strength properties of standard sheets

STRENGTH PROPERTIES OF STANDARD SHEETS CONDITIONED AT 65% R.H. AND 80°F.

10	11	12	13	14	15	16	17
Freeness of pulp	Basis weight	Breaking length	Stretch	Tear factor (Marx-Elmendorf)	Burst factor (Mullen)	Folding resistance (Schopper)	REMARKS
c.c. (C.S.F.)	g./sq. metre	metres	%			double folds	
230	61·0	8400	5·0	77·0	43·1	580	The pulp was under-cooked. Shives were present.
300	57·6	6600	5·0	77·0	31·3	170	The pulp was under-cooked. Shives were present.
250	58·9	6800	4·5	80·3	31·3	270	In Serial Nos. 3-8 well-cooked pulps free from shives were obtained.
200	62·2	7000	4·0	60·2	32·4	90	
320	59·0	6100	4·2	64·3	34·4	90	
200	62·7	8200	4·3	66·2	32·3	240	
325	61·4	5800	3·5	60·0	32·0	50	
265	60·2	6700	3·4	57·0	25·0	60	

TABLE IV.—PILOT

Digestion of Phragmites karka and of

1	2	3	4	5	6
Serial No.	Total chemicals*	Concentration of chemicals	Digestion temperature	Digestion period	Consumption of chemicals*
	%	g./litre	°C.	hours	%
1	22	45	162 for the first 4 hours and 153 for the remaining period.	6	20·0
2	22	40	162 for the first 2 hours and 153 for the remaining period.	6	21·6
3	22	40	162 for the first 3 hours and 153 for the remaining period.	6	21·6

* The % is expressed on the basis of the raw material (oven-dry).

TABLE V.—PILOT

Strength properties of papers from pulps described in Table IV, Serial Nos. in this Table

1	2	3	4	5	6		7		8	
Serial No.	Freeness	Ream weight 17½″ × 22½″ — 500	Basis weight*	Thickness	Tensile strength (Schopper)		Breaking length*		Stretch	
	c.c. (C.S.F.)	lb.	g./sq. metre	mils (1/1000 inch)	kilograms breaking strain for 1 cm. width		metres		%	
					Machine direction	Cross direction	Machine direction	Cross direction	Machine direction	Cross direction
1	150	17·4	57·3	3·75	1·86	1·12	3250	1950	1·6	2·4
2	200	18·1	59·9	3·90	1·66	0·97	2770	1620	1·4	2·0
3	170	17·0	55·9	3·40	1·60	0·99	2860	1770	1·2	2·0

* For calculating this, oven-dry weight of the paper was used.

PLANT TRIALS

a mixture of this species with Arundo donax

7	8	9	10
Unbleached pulp yield*	Bleach consumption as standard bleaching powder*	Bleached pulp yield*	REMARKS
%	%	%	
—	8·2	41·5	*Phragmites karka* was digested using the soda process. The pulp was well-cooked.
43·0	8·0	37·1	*Phragmites karka* was digested using the sulphate process. The pulp was well-cooked.
43·3	8·5	34·5	A mixture of equal quantities of *Phragmites karka* and *Arundo donax* was digested using the sulphate process. The pulp was well-cooked.

PLANT TRIALS

correspond to the Serial Nos. in Table IV. The papers were conditioned at 65% R.H. and 80°F.

9		10		11	12	13		14
Tearing resistance (Marx-Elmendorf)		Tear factor*		Bursting strength (Ashcroft)	Burst factor*	Folding resistance (Schopper)		REMARKS
g.				lb./sq. inch		double folds		
Machine direction	Cross direction	Machine direction	Cross direction			Machine direction	Cross direction	
21·2	22·4	37·0	39·1	10·5	12·9	3	2	Printing paper.
19·4	21·6	32·4	36·1	10·1	11·9	3	2	Writing paper. A sample is inserted in this bulletin.
23·0	25·2	41·1	45·1	13·6	17·1	7	4	Writing paper. A sample is inserted in this bulletin.

TOPSY-TURVY THINNINGS

BY PARTAP SINGH, I.F.S.

1. *Introductory.*—The writer submitted a paper, 'The Conception and Classification of Thinnings' to the Seventh All-India Silvicultural Conference 1946, which was later published in the *Indian Forester* (pages 315–322) of July 1947. At my own request the following footnote was added to it :—

> 'Paper read at the Seventh All-India Silvicultural Conference (1946), Dehra Dun, on item 15—Thinning Research. The Conference resolved that the technique proposed in this paper should be further examined with the collaboration of the author. Expression of views from readers will be welcome.—*Ed'*.

Four years have passed by and yet no views have so far been expressed. Inertia rules supreme. The ideas of freedom propounded in the new conception are so original and revolutionary that it smacks of heresy to the old forester, who the world over has for almost a century believed in the theory of dominance. Happy in his make believe that thinning can only be learnt in the field and not from books, he is not interested in any new theory particularly when ignorance is bliss. The case of research worker is somewhat different and it was to draw his attention that a further contribution 'Single Stem Silviculture and the Conception and Classification of Thinnings', was made which appeared in the issue of the *Indian Forester* (pages 73–77) for February 1948, but still no response came. Everybody seems to be waiting for something to happen, hoping that someone else will take up the challenge. The present attempt is to project the forest into the conference room so that the practical forester and the research worker may both be able to carry out a field test together, before accepting the new conception and classification. This paper must, therefore, be read in conjunction with the two previous contributions of which the present is a further exposition.

2. *The Forest.*—Just adjoining the compound of the Manali Forest Rest-house, a picturesque place in the beautiful Kulu valley, visited annually by forestry students from all over India, lies Sample Plot No. 3 (started in 1904) which contains a pure crop of deodar (*Cedrus deodara*) raised artificially in 1877. Thinned as required to start with, the grade was first fixed at 'C' and then changed from 'C' to 'D' in 1931, actually approaching nearer 'E' than 'D' 10 years later. Interim measurement recorded in 1946 shows the area of the plot as equal to 0·56 acres, of site quality I, carrying 84 trees (or 150 trees to the acre, 18½ feet apart on an average), 70 years old, with an average diameter of 17·2 inches and a top height of over 106 feet. In 1947 the plot was completely mapped by the writer with regard to the extent of the free crown of each tree, of which the total height and crown length (taken by a hypsometer) were also recorded. The table below gives not only detail of dimensions of trees, trunks and crowns but also their classification under the current research practice (as recorded in Sample plot file) as well as under the proposed technique. The extent of free crown of each tree is mapped in Figure 1.

3. *The Dilemma.*—The next thinning is scheduled for the current year (1951) which poses the problem of how best to mark it. Officially the grade to which the crop is to be subjected is 'D' which includes the removal of dead, dying, diseased, suppressed, dominated and some of the dominant trees but the only classes differentiated in the crop are dominants and co-dominants. Would a 'D' grade of thinning be carried out by removal of all the co-dominants of which there are only 7 ? Would it be correct to remove all the co-dominants at once ? Should some of the dominants be also marked along with the co-dominants, and

TABLE I.—*Record of Tree Measurements*

Tree No.	Diameter	Length of		Height of tree	Classification by			
					Dominance		Freedom	
		Stem	Crown		Dominant	Co-dominant	Spaced	Sub-spaced
	inches	*feet*	*feet*	*feet*				
1	22	75	32	107	Ia	..	Ia	..
2	20	68	34	102	Ia	..	Ia	..
3	19	76	38	114	Ia	..	Ia	..
4	17	57	39	96	Ia	..	Ia	..
7	17	66	28	94	Ia	..	Ia	..
9	15	70	23	93	..	2a	Ia	..
10	15	71	26	97	Ia	..	Ia	..
11	16	75	25	100	Ia	..	..	IIa
13	16	68	30	98	Ia	..	Ia	..
15	14	68	25	93	Ia	..	..	IIa
17	19	66	33	99	Ia	..	..	IIa
18	19	60	36	96	Ia	..	Ia	..
20	19	52	32	84	..	2a	..	IIa
23	21	70	41	111	Ia	..	..	Ia
25	12	60	28	88	..	2a	..	IIa
26	18	68	40	108	Ia	..	Ia	..
28	19	72	35	107	Ia	..	Ia	..
31	20	73	33	106	Ia	..	Ia	..
33	16	68	30	98	Ia	..	Ia	..
34	17	60	36	96	Ia	..	Ia	..
36	16	70	34	104	Ib	..	Ib	..
38	17	70	37	107	Ib	..	Ib	..
40	19	68	28	96	Ia	..	Ia	..
45	18	62	30	92	Ia	..	Ia	..
47	18	60	32	92	Ia	..	Ia	..
49	17	68	36	104	Ia	..	Ia	..
50	16	64	36	100	Ia	..	..	IIa
51	16	66	30	96	Ia	..	..	IIa
53	19	64	36	100	Ia	..	Ia	..
54	18	66	30	96	Ia	..	Ia	..
56	14	68	24	92	Ia	..	..	IIa
61	20	68	35	103	Ia	..	Ia	..
63	16	68	34	102	Ia	..	..	IIa
64	13	64	34	98	Ib	..	..	IIa
66	18	68	36	104	Ia	..	Ia	..
68	21	68	32	100	Ia	..	Ia	..
73	17	70	32	102	Ib	..	..	IIa
74	18	69	31	100	Ia	..	Ia	..
76	15	70	32	102	Ia	..	Ia	..
78	17	70	32	102	Ib	..	..	IIa
79	19	73	32	105	Ia	..	Ia	..
81	19	75	35	110	Ia	..	Ia	..
82	24	80	36	116	Ia	..	Ia	..
87	15	60	38	98	..	2b	Ib	..
93	16	70	30	100	Ia	..	Ia	..
103	19	60	47	107	Ia	..	Ia	..
107	15	71	30	101	Ib	..	..	IIb
112	18	75	34	109	Ia	..	Ia	..
117	14	Half fallen		..	Ia	..	..	IIb
122	18	70	35	105	Ia	..	Ia	..
127	13	69	30	99	..	2a	..	IIa
129	15	68	30	98	Ia	..	Ia	..
135	14	67	25	92	Ia	..	Ia	..
140	23	70	39	109	Ia	..	Ia	..

(contd.)

TABLE I.—*Record of Tree Measurements*—(concld.)

Tree No.	Diameter	Length of		Height of tree	Classification by			
					Dominance		Freedom	
		Stem	Crown		Dominant	Co-dominant	Spaced	Sub-spaced
	inches	*feet*	*feet*	*feet*				
146	17	60	46	106	Ib	..	Ia	..
149	19	71	38	104	Ia	..	Ia	..
153	18	71	30	101	Ia	..	Ia	..
158	19	71	35	106	Ia	..	Ia	..
162	18	56	40	96	Ia	..	Ia	..
170	20	64	32	96	Ia	..	Ia	..
175	17	70	36	106	Ia	..	Ia	..
181	18	71	35	106	Ia	..	Ia	..
188	19	76	30	106	Ia	..	Ia	..
191	17	70	36	106	Ia	..	Ia	..
198	17	78	28	106	Ia	..	Ia	..
205	18	70	34	104	Ia	..	Ia	..
208	12	70	26	96	..	2a	Ia	..
211	19	74	32	106	Ia	..	Ia	..
218	18	69	32	102	Ia	..	Ia	..
224	18	71	35	106	Ia	..	Ia	..
236	13	69	27	96	Ia	..	..	IIa
239	15	75	28	102	Ia	..	..	IIa
241	20	70	36	106	Ia	..	Ia	..
246	20	76	30	106	Ia	..	Ia	..
250	21	71	41	112	Ia	..	Ia	..
257	17	70	35	105	Ib	..	Ia	..
263	18	77	30	107	Ia	..	..	IIa
267	18	53	35	88	Ia	..	Ia	..
268	14	68	26	94	Ia	..	..	IIb
269	15	68	28	96	Ia	..	..	IIb
270	15	68	35	103	Ia	..	..	IIa
272	18	60	36	96	Ia	..	Ia	..
274	15	69	21	90	..	2a	..	IIa
275	16	83	22	105	Ia	..	Ia	..
Total 84	..	..	..	..	77	7	62	22

if so to what extent ? While these questions cross the mind of the research worker the plight of the executive forester, who does not differentiate between the dominants and co-dominants in carrying out the thinning may well be imagined. The idea of a Silvicultural thinning, as sometimes talked about, is simply absurd ; it is based on nothing and can be checked by nothing. It is a mere whim.

4. *Marking a 'D' grade.*—How should the required 'D' grade be then marked ? The executive forester is flabbergasted by the absence of dominated and suppressed classes from the crop and would not know how many of the dominants should go unless he takes courage in both the hands, marks a 'Silvicultural' and declares it 'D'. The research worker will remove all the 7 co-dominants (Nos. 9, 20, 25, 87, 127, 208 and 274) though almost half of them (Nos. 9, 87 and 208), as will easily be seen from Figure 1, do not require to be removed at once. (Table I shows that some trees classed 2 are class I according to new conception). But his main problem remains ; he is not sure how many of the dominants should also come out and which. He consults the 'multiple yield tables for deodar by Champion and Mehindru'

and finding that it is expected to take out 19 trees per acre or 12 from the crop in question, goes back and marks another 5 or so trees with satisfaction. Unknowingly (but instinctively) he marks the worst sub-spaced trees (Nos. 15, 25, 64, 117, 268 or and 269) in accordance with the new 'freedom' theory. Where dominants differentiation fails you in older crops and higher grades of thinnings the freedom differentiation remains.

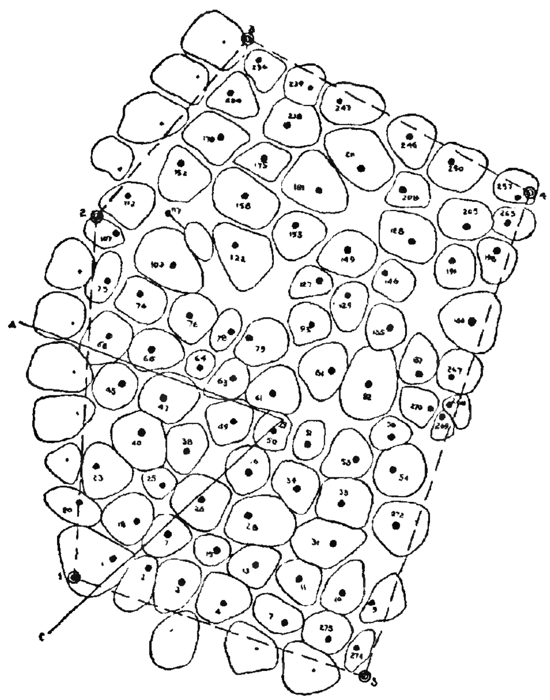

Fig. 1:- PLAN SHOWING PROJECTION OF FREE CROWNS OF TREES.
SAMPLE PLOT No. 3.
KULU FOREST DIVISION
SCALE 1" = 30FT.

5. *The new conception.*—If thinnings cannot really be done the old way why not give it up and replace your faith by reason. The new conception tells you that thinning is a function of numbers and the numbers left at different stages (regime) determine the development of the crop. As a corollary to this, the classification of trees is logically based on freedom of the crown, which tells you exactly what trees to remove. Table I shows that there are 22 'sub-spaced' trees in the crop and if a thinning regime requires 12 trees to be removed a look at Figure 1 would show that Nos. 15, 25, 50, 56, 64, 73, 78, 107, 117, 263, 268 and 269 are easily indicated (see also Figure 2) and the grade of thinning would be 'light sub-spaced'. There is no question of thinning marking being possible only in the field. Almost these very numbers were selected from the mapped plan, Figure 1, by the lowest subordinates entrusted with thinning markings and verification later in the field that numbers selected were really such trees that would do the greatest good to the remaining crop, brought them great professional delight.

6. *Useful applications.*—The Kulu Working Plan has recently been revised and the data collected shows that the distribution of growing stock to the five Periodic Blocks (rotation being 150 and period 30 years) is irregular. Suppose now that the Sample Plot No. 3

represented a forest, which in consideration of its age should be alloted to P.B. III but has actually been alloted to P.B. II, on account of the shortage of older age classes. The age of the crop, from the point of view of management, having been increased, fewer trees per acre will have to be left in accordance with the prescribed regime than if the plot (forest) had been alloted to P.B. III. In other words a heavier grade of thinning, that is a 'heavy sub-spaced' grade involving removal of nearly all the 22 sub-spaced trees, will be carried out to promote rapid diameter growth and make the crop more if not fully exploitable by the time its turn comes for felling. Otherwise the crop would remain undersized. It will be noticed that grade of thinning is determined by requirements of management rather than be fixed arbitrarily or silviculturally at C or D.

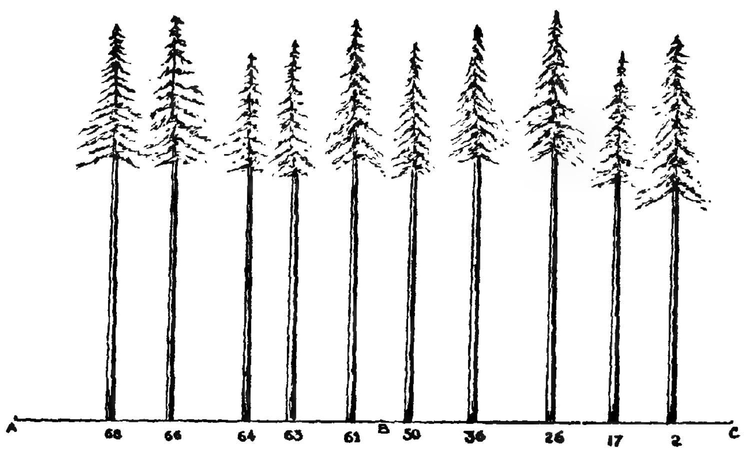

Fig.2.:-CROSS SECTION OF CROP ALONG LINE A.B.C. MARKED ON Fig.1.

SCALE 1" = 30 FT.

Every tree being dominant under the old classification confuses thinning. Under the new classification, sub-spaced trees Nos. 17, 50 & 64 offer themselves for removal.

Another practical application is determining the regime and grade of thinning kail (*Pinus excelsa*) crops managed along with deodar in one and the same working circle for the same exploitable size under the same rotation of 150 years. Kail crops as yield tables would show, are much faster growing in diameter as compared to deodar and, therefore, a much lighter grade of thinning, leaving a larger number of trees in the growing stock is indicated. A comparative table showing the regimes for deodar and kail is given below :—

Periodic Block	Number of stems per acre		Spacing trees in feet	
	Deodar	Kail	Deodar	Kail
I	800	550	8	9–10
V	500–300	375–275	10–13	12–14
IV	220–140	210–165	15–19	16–18
III	125–100	135–120	20–22	19–21
II	95– 80	108–100	23–25	22–23

7. *Topsy-turvy thinnings.*—The practical applications mentioned in the last paragraph are bound to appear opposed to prevalent ideas. Of course they are ; and so are many others as will be noticed by a careful perusal of the previous two contributions. It will be of interest to the reader to know what the new theory implies. It means :—

1. A thinning is determined by the number of trees left and not by the kind of trees removed.
2. Thinning is a continuous process connected with and affected by the past and future thinnings in accordance with a regime.
3. Grade of thinnings is a rough measure and guide which has no relationship with the regime.
4. Relative height of trees has little significance in thinning as compared to free crown spread and can, therefore, be ignored.
5. Logical tree and thinning classification is based on freedom of crown and not dominance.
6. Best representation of thinning operations is made in plan than in elevation.
7. The idea of a thinning cycle is incompatible with regimes, the latter being for all practical purposes independent of the first, which is determined by management.
8. Regimes make calculations of a rotation period unnecessary in preparing Working Plans. It can be fixed arbitrarily to suit the management and a corresponding regime adopted. It implies independence of a Silvicultural thinning regime.
9. Regimes make management independent of site quality by leaving more trees per acre on better soils and fewer trees on poorer soils.
10. Similarly when crops are mixed in one and the same forest more of the faster growing trees must be left per acre than the slow growing species.

It will be seen that the new conception of thinnings is not only very different but diametrically opposed, both literally and metaphorically, to the old.

Isn't it topsy-turvy ? No, it was.

EUROPODA NYMPHS ON LYCTID AND CURCULIONID BEETLES

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While examining the beetles of *Lyctoderma ambiguum* Lesne (Fig. A) (Lyctidae : Coleoptera) in the reference collection of the Entomology Branch, I noticed several nymphs of a mite belonging to the genus *Europoda* (Parasitidae : Acarina) attached to the various parts of the body of these lyctid beetles. This lyctid species was bred in a large series during October and November 1926 from the wood of *Acacia catechu* brought from Rahatgaon, Hoshangabad, Madhya Pradesh. Recently, some *Uropodid* nymphs were also observed on the body of a species of weevil, *Mecistocerus fluctiger* Faust (Fig. B) (Curculionidae : Coleoptera). These weevils had emerged during May–June 1951 from the wood *Sapium insigne*, collected from Dhoran, Dehra Dun, U.P., in October 1950. Eleven individuals out of 30 lyctid beetles and 43 individuals out of 377 weevils bore the nymphs of this mite. These nymphs were found attached to the prothorax, elytra, legs or ventral side of the beetles. On some regions of the body, the nymphs were closely crowded together, thus overlapping one another. Each mite nymph was fixed to the integument of the beetle by a minute white pedicel present at the posterior end. This nymphal form is known as "*nympha pedunculata*". In this stage, these mites are said simply to be clinging to the beetles as a means of transportation (Banks, 1904, 1915), and thus lead a more passive existence. During this period they take no food and are, therefore, not a true parasite, and their dispersal depends to a greater degree upon the movement of their host for food. These mites drop off when they find suitable breeding places.

There are several other parasitic species of mites which at times are found in great numbers in the galleries of bostrychids, buprestids, cerambycids, curculionids and scolytids where they destroy the eggs, larvae, pupae, and even the newly-formed adults.

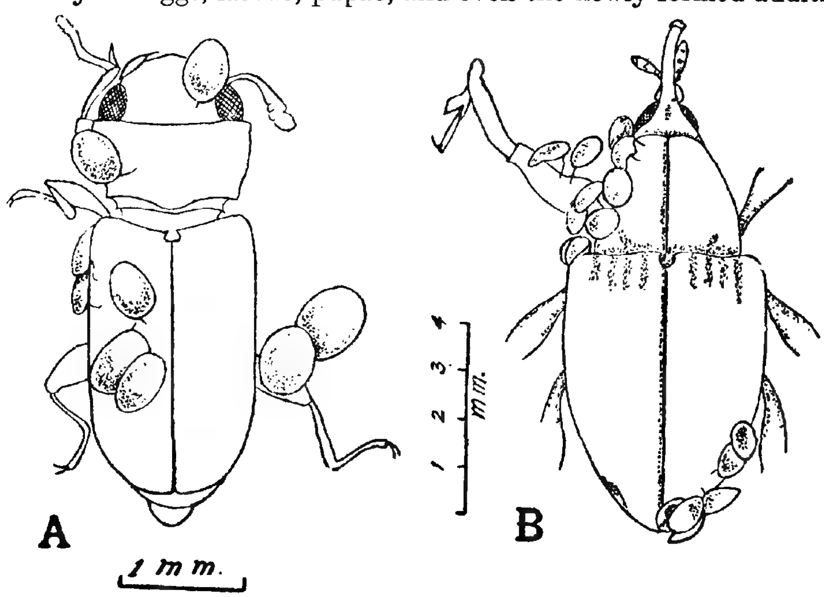

FIG. A.—Dorsal view of *Lyctoderma ambiguum*, covered with *Europoda* nymphs.
FIG. B.—Dorsal view of *Mecistocerus fluctiger*, covered with *Europoda* nymphs.

The number of *Europoda* nymphs counted on different regions of the body of these beetles is recorded below :—

On Lyctoderma ambiguum beetles

Ventral side of the body ..	39	mite nymphs on	8	individuals.
Head	2	,, ,, ,,	2	,,
Prothorax	1	,, ,, ,,	1	,,
Elytra	12	,, ,, ,,	4	,,
Femora of legs ..	6	,, ,, ,,	5	,,

On Mecistocerus fluctiger beetles

Prothorax	59	mite nymphs on	26	individuals.
Elytra	47	,, ,, ,,	19	,,
Femora of legs ..	23	,, ,, ,,	19	,,
Ventral side of the body ..	8	,, ,, ,,	6	,,

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Non-Cereal Foods

TUBERS OF *DIOSCOREA HISPIDA* DENNST

BY P. S. RAO AND R. M. BERI

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In an earlier publication[1] has been indicated the need for the discovery of non-cereal food materials from apparently non-edible sources to meet the present shortage of normal foodgrains in the country. In continuation of the work in progress in this direction, the tubers of *Dioscorea hispida* Dennst (syn. *D. dœmona* Roxb.) have been examined.

D. hispida is a considerable climber which is found throughout India to some extent but more extensively in the peninsula along the coastal tracts and the hilly forests up to a height of 1,000 ft. Its tubers, which are called *pashpoli* or *marapashpoli* in Sanskrit, *karukanda* in Hindi, *baichandi* in Marathi, *pulidumpa* in Telugu, *peiperendai* in Tamil and *podava-kilangu* in Malayalam, are quite bulky. The normal ones usually weigh a few pounds but cases are known where a large tuber (in Singapore) weighs as much as 77 lb., and sometimes even more. They are described as "one of the most important natural famine foods"[2,3,4]. They are said to possess some medicinal properties also. For instance, they are made into a paste in admixture sometimes with lime and sometimes with turmeric and benzoin and applied to sore feet and wounds which are infested with maggots. Their decoction in water is said to act as an alterative and diuretic in chronic rheumatism.

But the tubers contain certain alkaloids called dioscorine and dioscoricine which are poisonous not only to human beings but also to animals like tigers, etc. Hence in the natural condition they are not edible, and if eaten, they cause nausea, giddiness, vomiting of blood and suffocation and sometimes even death. They must, therefore, be "prepared", if they are intended for human consumption. The common way prevalent amongst the local inhabitants of effecting the removal of the poisonous principles is to rasp the tubers and repeatedly wash the material with water, preferably containing some salt. Sometimes boiling is also resorted to. The whole operation takes about 3 to 4 days for a complete removal of the alkaloids.

Since the tubers appear to be available in good abundance, they have now been examined with a view to eliminating the poisonous alkaloids in a simple and yet effective way, so that edible flour or starches as the case may be, can be prepared out of them. The tubers were obtained from the Bilaspur Forest Division, and at the time of their arrival they were in a partially-dry condition. After soaking for sometime in water, they were washed well to remove any adhering dirt and peeled off mechanically with a knife. The debarked roots (1 kg.) were taken, cut into halves lengthwise and then into small bits and dried in the sun, when they were reduced to about 200 grams. Experiments with fresh roots indicated that they contain 70 to 80 per cent of water. The dry material, when powdered to 80-mesh fineness, yielded a product which was light yellow in colour (1·4 yellow and 0·9 red against the standard white of Lovibond tintometer). It contained 10·65 per cent of moisture. The absolutely-dry powder (zero moisture) analysed as follows (Table I). For the sake of comparison the values as recorded by Hooper[4] are also given. The analysis was carried out according to the standard methods as given in the "*Methods of Analysis*" of the Association of the Official Agricultural Chemists (A.O.A.C.) and in Allen's "*Commercial Organic Analysis*".

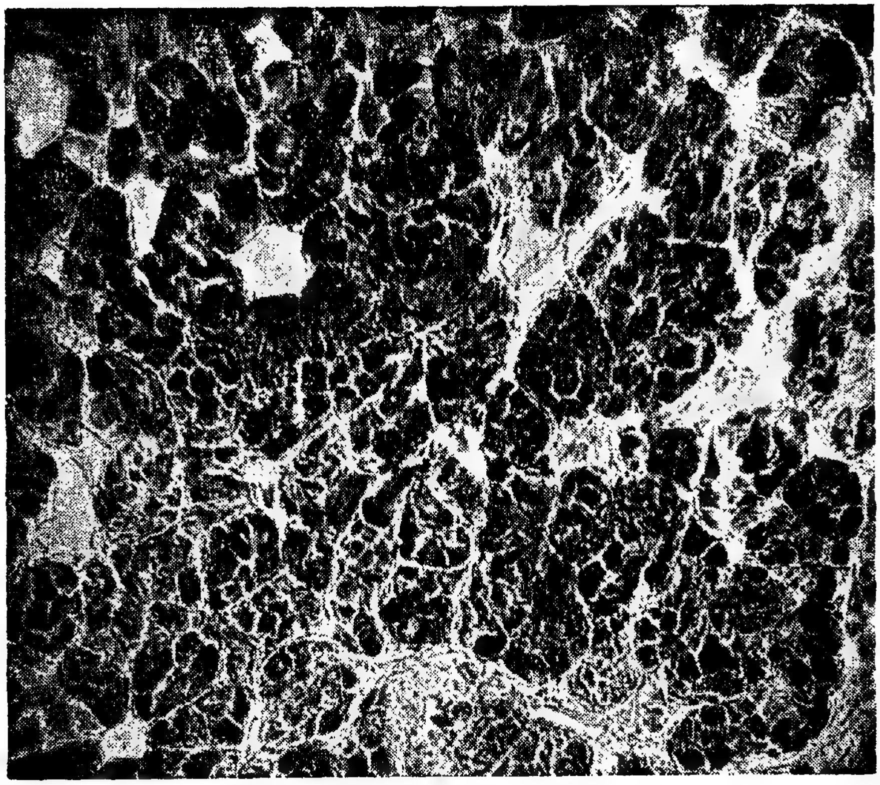
TABLE I.—*Analysis of D. hispida flour*

	Unprocessed flour		Processed flour
	Hooper's values	Values of the authors	
Fat	0·97– 1·10%	2·00%	0·23%
Albuminoids.. ..	7·20– 9·12%	5·82%	5·28%
Fibre	3·28– 6·28%	6·58%	5·33%
Carbohydrates ..	81·45–81·89%	81·75%	88·34%
Ash	4·05– 4·61%	2·97%	0·66%
Colouring matter (Alcohol-extracted) ..	..	1·14%	..

In the ash were found Na^+, K^+, Ca^{++}, Mg^{++} and Al^{+++} as the metallic radicles and CO_3^{--}, SO_4^{--} and NO_3^- as the acid radicles. Some silica was also present.

The powder contained 0·19 per cent of the poisonous alkaloids. It was found that, when the powder was suspended in 4 to 5 times its weight of saturated lime water containing 0·005 per cent of potassium permanganate, and thoroughly agitated for an hour, the alkaloids were oxidized into easily-soluble products. When the reaction mixture was subsequently acidified with hydrochloric acid and treated with a small amount of sodium bisulphite, the excess of potassium permanganate and the liberated manganese dioxide were all converted to soluble colourless products. After standing for 3 to 4 hours the purified flour that settled down was filtered, washed with small amounts of water and alcohol and dried at the ordinary temperature (30°C.) in air. This material was very pale creamy in colour. When tested for alkaloids, it did not give any indication of their presence. It contained 13·26 per cent of moisture. Its other analytical data as calculated on zero-moisture basis are given in Table I under "Processed flour". The substance was partly soluble in cold water and more so in hot water. The aqueous solutions, when treated with iodine, produced a deep blue colour, characteristic of starch. For identifying the nature of the sugars constituting the carbohydrate portion, a small amount of the powder (5 g.) was boiled under reflux with 200 c.c. of 5 per cent sulphuric acid for 4 hours. After cooling, the hydrolysate was filtered, neutralized with just the required amount of barium hydroxide, filtered and the filtrate analysed for sugars and uronic acids according to the recently-developed paper-chromatographic technique of Rao and Beri[5]. Except glucose no other sugar or uronic acid could be detected. The presence of glucose was confirmed by the formation of glucosazone with its characteristic crystalline structure and melting point (204°–206°). Confirming the absence of uronic acids, the substance did not liberate any carbon dioxide, when boiled with 12 per cent hydrochloric acid according to the method of Dickson, Otterson and Link[6]. It did not contain any pentosans also, since, on boiling with 12 per cent hydrochloric acid (method of Krober, as modified by Angell, Norris and Resch[7]), no furfural was liberated.

The main constituent of the tubers of *D. hispida* was, therefore, starch. In further confirmation, a microscopic examination of sections of the tubers was made. On treatment of the sections with iodine and washing off the excess of the reagent, starch granules were distinctly seen in the sections, when examined under the microscope. The granules were non-stratified and oval-shaped, the length being slightly less than double the width. The longitudinal diameter of the granules varied from 25μ to 40μ, the majority being between 35μ to 40μ.



Dioscorea hispida tuber cross section showing starch grains.

For the isolation of the pure starch, the purified *D. hispida* flour was boiled with 20 times its weight of water for an hour, when a viscous solution was produced. The extract was first filtered through cloth and then passed through a centrifuge to remove the suspended impurities. It was then treated with four times its volume of alcohol, when the starch separated out as a white crisp powder. It was filtered, washed with alcohol and dried in the air.

In aqueous solution it gives with iodine the characteristic deep blue colour, and exhibits a specific rotation of 148·7° at 30° (conc. = 0·4 per cent). Its specific gravity in the anhydrous condition is 1·3201. The analysis and other properties of this starch are presented in the following table. For the sake of comparison, the data for sweet and white potato starches[8] are also included.

TABLE II

	D. hispida starch	Sweet potato starch	White potato starch
Moisture	9·07%	8·02 –15·85%	11·87 –17·33%
Proteins	1·53%	0·018–0·306%	0·100–0·175%
HCl-insoluble material ..	0·435%	0·063–0·168%	0·083–0·200%
Ash	0·375%	0·113–0·396%	0·247–0·365%
Gelatinization temperature	85°C.	74°C.	66°C.

In 3 per cent concentration the viscosity of the starch solution (measured with Stormer viscometer in terms of fifth-seconds for 100 revolutions of the rotor with 50 grams as driving weight) at 90° is in between those of rice starch (now determined) and corn starch (taken from literature), and attains the maximum after heating for 60 minutes. The viscosity does

not fall appreciably, even when the solutions are heated for 6 hours. In this respect it resembles corn and rice starches and differs from cassava and white potato starches[9] as shown below :—

TABLE III.—*Viscosity at 90°C. in fifth-seconds*

Starch (3% paste or solution)	After heating at 90°C. for						
	15 mins.	30 mins.	60 mins.	120 mins.	180 mins.	240 mins.	360 mins.
Corn[9]	74	75	76	72	69	67	65
Rice (B.D.H. Sample)..	39	40	40	40	40	38	37
White Potato[9] ..	9,670	11,076	6,324	3,308	..	961	585
White Potato (B.D.H. Sample) ..	710	478	282	206	144	101	77
D. hispida	55	57	58	56	56	55	54

It is, therefore, clear that the *D. hispida* flour is nearly 90 per cent of starch, while the rest is made up chiefly by fibre and proteins in almost equal amounts. This is quite suitable for industrial purposes, where the presence of a little colour does not matter. It can also form the raw material for the glucose and the starch industries. For its direct use as food, it is suggested that the nutritional and the toxicological properties, if any, may be got examined at the appropriate institutes. Now-a-days, on account of the shortage of rice in the country, suggestions are afloat for the production of "synthetic rice" from tubers and millets[10], and for this purpose the processed *D. hispida* flour may be quite suitable as a starting material.

MANUFACTURING DETAILS

From experiments carried out on a large scale in the laboratory the following scheme is suggested for the manufacture of the flour (Fig. 1) and starch (Fig. 2) from the tubers of *D. hispida* at a factory level. The operations are almost the same as those adopted for the manufacture of starches from tubers in general [8, 9, 11, 12] and sweet potatoes in particular [8, 13].

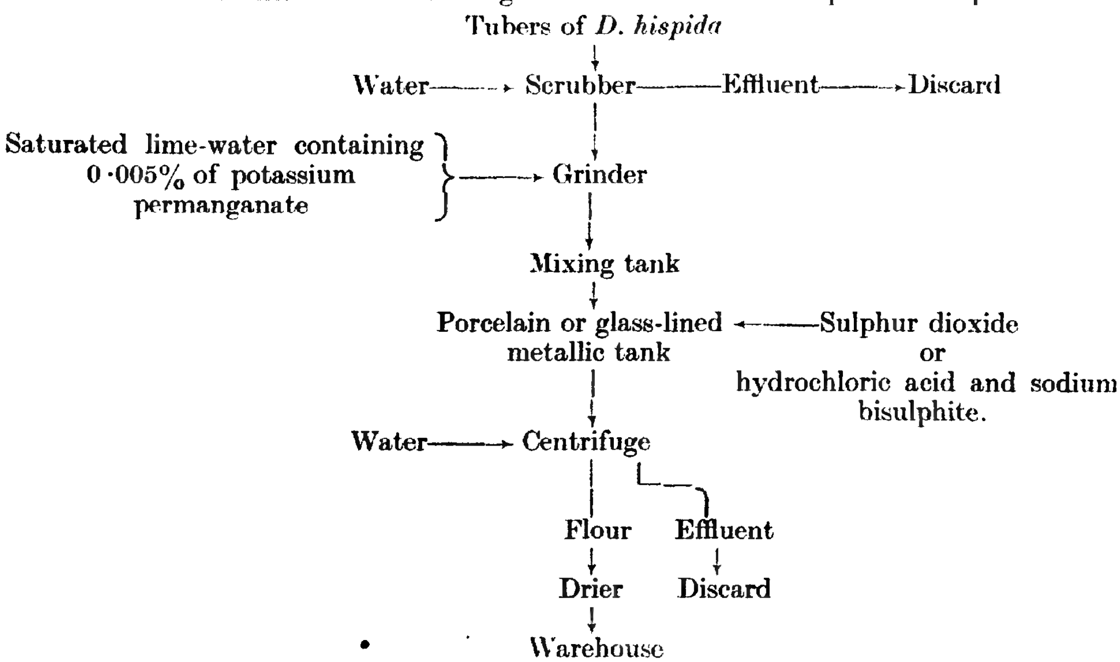


FIG. 1.—Flow diagram for the manufacture of edible *D. hispida* flour.

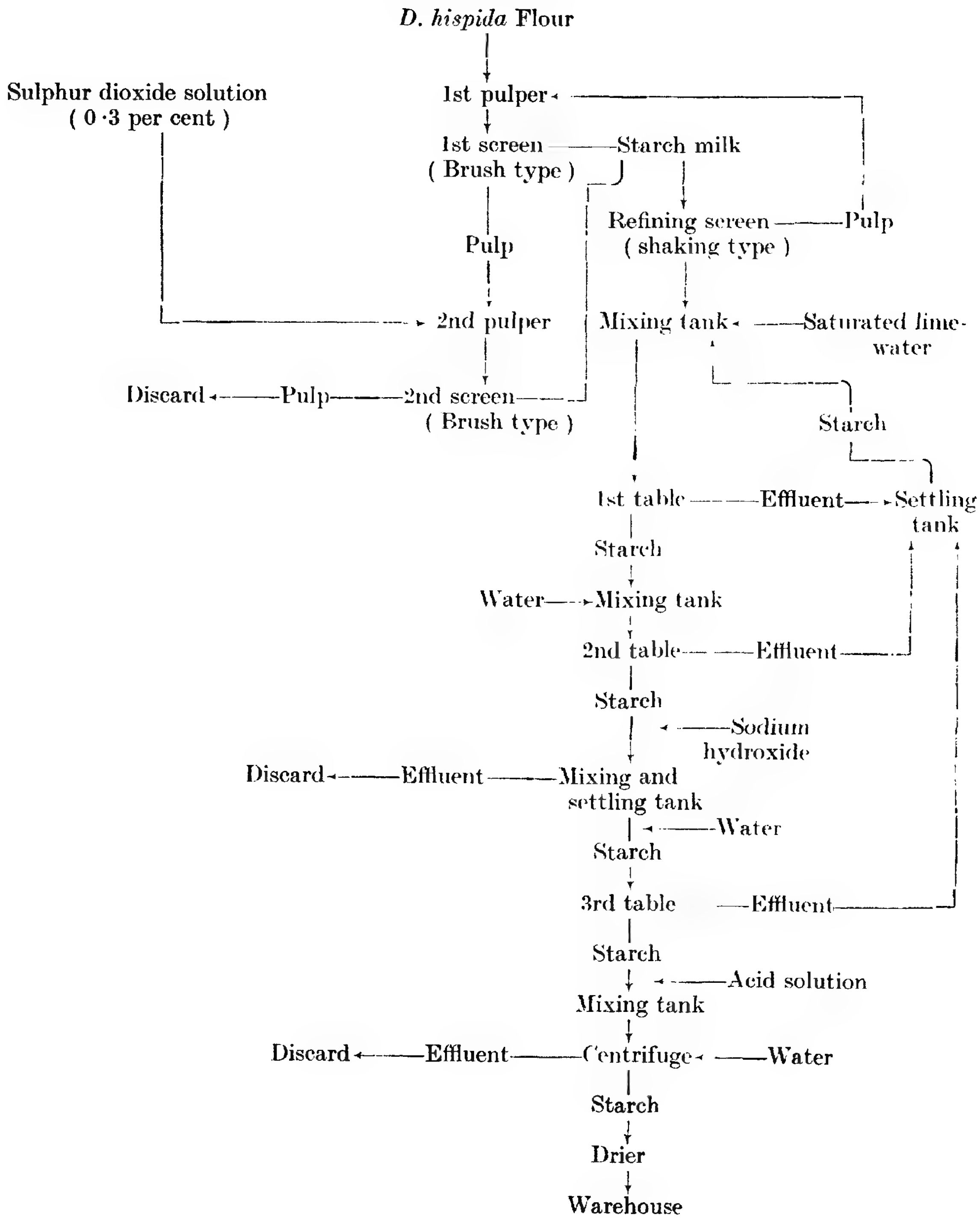


FIG. 2.—Flow diagram for the manufacture of starch.

Washing.—The tubers as collected from the forests are naturally coated with dirt, mud and filth. The first step is, therefore, to clean them. This is done by a thorough washing by hand or in machines. In the latter case, a scrubber or a revolving cylinder which may be either of wood or of heavy wire is used. The sides of the cylinder, if made of wood, are perforated to allow water to flow in and flow out easily. The scrubber, partly immersed in a tank of running water, rotates on an inclined axis. The tubers are tumbled into it from the top, and the jostling and rubbing during rotation effect the cleaning of the tubers.

Pulping.—For the preparation of the flour, the tubers may be mashed in a potato-rasping machine. However, for the manufacture of starch this operation will not do, since the granular size of *D. hispida* starch being much smaller than that of white potato starch, the walls of the cells will not be sufficiently ruptured as to liberate all the starch completely. The tubers should, therefore, be more finely ground, though not so finely as in the case of sweet potatoes. This can be done in rollers or buhr stones. The water that is used during this operation, as in all subsequent operations, should be pure, soft and free from iron, as otherwise the small amounts of tannin present in the roots tend to discolour the product.

Treatment with lime-water and potassium permanganate.—The amount (by weight) of lime-water which is to be used in the preparation of the flour is five times the weight of the tubers to be taken, and potassium permanganate is in such an amount as to form 0·005 per cent solution in the lime-water. During this treatment the poisonous alkaloids present in the tubers get oxidized to easily-soluble products so that they are eliminated at the subsequent stage of centrifuging. To ensure the complete destruction of the alkaloids the $KMnO_4$-treated powder is mechanically stirred in the mixing tank for an hour.

Removal of excess of potassium permanganate and the separated manganese dioxide.—This is done by passing sulphur dioxide into the $KMnO_4$-treated product till all the colour is discharged. Alternatively, the product is acidified with hydrochloric acid till the pH falls to 4, and then it is treated with sodium bisulphite, in small amounts, till the permanganate colour disappears. About $1\frac{3}{4}$ parts of bisulphite will be required for every part of permanganate used. In sulphurous acid solution the product is allowed to remain for 3 to 4 hours, since this treatment effects the removal of the yellow colouring matter present in the tubers.

Screening.—The first and the second screenings are done in 100-mesh sieves of the brush type, and during these two operations almost the whole of the starch along with some fibre is forced down. The third screening which is done by a 150-mesh sieve of the shaking type effects refinement of the product from the fibre which might have passed through the first two sieves.

Centrifuging.—Perforate-basket type of centrifuges[14] are suitable for the isolation of the starch or the flour from the aqueous suspensions.

Drying.—The product that leaves the centrifuge contains about 35 per cent of water. To dry this any type of drying may be adopted—belt drying, grid-drying or drum-drying. But a convenient method in which the formation of gelatinized starch is prevented is the use of vacuum drum-driers, where the internal temperature ranges from 35° to 40°C. The resulting product usually contains about 10 per cent of moisture.

Pulverizing and Screening.—The dried starch is pulverized to the required fineness in the buhr or roller mills and screened in a sieve of the appropriate mesh.

Since *Dioscorea hispida* is a forest plant distributed over a wide area, the situation of the factory for the manufacture of starch may not be within an easy reach of the collection centres of the tubers, and the latter, if in fresh condition, may get spoiled by the time they are transported to the factory. In such a case, the tubers may be thoroughly washed at the collection area, and the outer bark peeled off mechanically with knives. The debarked

roots, after being cut into halves lengthwise and then into small bits, may be dried in the sun and then conveyed to the factory. At the factory, the dried tubers are first steeped in water for about 6 hours and then subjected to the operations described above.

ACKNOWLEDGEMENT

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ROADSIDE AVENUE PLANTATION TECHNIQUE

As practised in Southern Doab Division, Etawah

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SUMMARY

Roadside avenue planting presents a problem different from raising of ordinary forest plantations. On roadsides protection of the plants presents the main difficulty. The technique evolved in Southern Doab Division of U.P. and now applied in whole of the Land Management Circle, U.P., is described.

GENERAL

1. In this note the method of roadside plantation as adopted in Southern Doab Division, Etawah has been described. The technique has been developed by gradual experience and by trial and error. It may not be perfect but a very large measure of success has been obtained by this technique in the Southern Doab Division, and other divisions in the Land Management Circle, U.P.

2. Roadside planting in Southern Doab Division has so far been confined to the P.W.D. roads in Kanpur District. The soil is fertile Gangetic alluvium, but there are frequent usar patches of varying degrees of alkalinity. Water logging of soil and presence of kankar pan in the sub-soil are also not uncommon.

CLIMATE

3. The climatic conditions are typical of the U.P. plains. The diurnal temperature range is from 40°F. to 80°F. during winter and 80°F. to 110°F. during summer. At times the mercury touches 120°F. mark during summer. Winters are cold and frosts do occur. During May and June there are hot winds (*loo*) blowing throughout the day. During March and April frequent wind and dust storms occur and take heavy toll of roadside and other scattered trees. Annual rainfall varies from 25 to 35 inches.

4. Sources of water supply on the roadsides are limited to the wells and canals.

SOIL PREPARATION

5. Soil preparation is done during the winter immediately after the winter showers when the soil becomes soft. During the summer soil preparation becomes extremely difficult as the soil becomes extremely hard to dig. Pits 2 feet deep and 2 feet in diameter are dug for the main avenue plant. Round these, circular trenches with internal and external diameters of 6 feet and 10 feet respectively and 1½ feet depth are dug. The dug out earth is heaped on the periphery of the central pit and the trench and is allowed to weather throughout the summer. Before the break of the monsoon the trenches are refilled with this earth and sown thickly with *babul* (*Acacia arabica*) for creating a live hedge.

6. The central pits used to be kept about 19 feet from the centre of the road for roads with 12 feet wide metalled surface, but this spacing has been changed recently to the spacing prescribed by the Road Congress for Provincial and National Highways. The current Road Congress convention is to plant the roadside avenues 35 feet away from the centre of the road,

for National Highways, and 30 feet away for the Provincial Highways. Along the length of the road the spacing between individual plants is 40 feet. Where trees from the existing tree line have to be accommodated this spacing has to be adjusted.

7. On aesthetic considerations, the pits should be symmetrically opposite on both sides of the road. This is very important, because pure avenues with regularly spaced trees look much more beautiful than avenues with irregularly spaced trees.

NURSERY PRACTICE

8. Work in the nursery is confined to the raising of vigorous large-sized seedlings for preparing transplants. The size of the transplants required varies with different species.

9. Transplanting is done on the ordinary bamboo orange baskets. Transplanting into the baskets is a very costly method of planting but it facilitates the transport of planting stocks over long distances without injuring rootlets, and is the only method which has given success on the roadside avenues. In order to minimize the period of protection required by the plant to enable it to establish itself, it is essential that the largest possible and most vigorous seedlings are used for transplanting into the baskets. Such transplants stand the extremes of climate much better and establish quicker.

10. In Southern Doab Division, the chief species used for roadside avenue-planting are *shisham* (*Dalbergia sissoo*), *imli* (*Tamarindus indica*), *jamun* (*Eugenia jambolana*) and *am* (*Mangifera indica*). There are other accessory species such as *nim* (*Azadirachta indica*), *kanji* (*Pongamia glabra*), *arjun* (*Terminalia arjuna*), *mahua* (*Madhuca latifolia*), *bahera* (*Terminalia belerica*), *siris* (*Albizzia procera*), etc. These accessory species are planted either in places where the main species have little chance of success on account of the soil conditions (e.g., *nim* and *arjun* in usar soils) or for their importance otherwise (e.g., *mahua* flowers and fruits).

11. In the case of *shisham* one year old seedlings are used. *Shisham* sown in the nursery beds in May and June becomes 10 to 12 feet in height by May and June the following year, when transplanting into the baskets is done. In the case of *jamun*, mango, *imli*, and *mahua*, one year old seedlings are too small. These species generally reach a height of 4 feet, 3 feet, 3 feet and 3 feet respectively in the first year. Up to 1949, only one year old transplants of these species were used, and were found to grow feebly and required much more individual attention. But in 1950 planting 2 year old transplants of *jamun*, *imli* and mango were used and were found to do very much better and all of them have established themselves. The average heights of these plants at the time of planting were—*jamun* 8 feet, mango 5 feet 6 inches, and *imli* 5 feet. It is interesting to record that the height of these 1950 plants is greater than the plants put in 1949, where one year old seedlings were used. Thus the period of protection in 1950 planting has been reduced by at least one year and the cost, by at least one rupee per plant. Two year old basket transplants of *mahua* also appear suitable but this needs trial on the field. In poorer soils it is contemplated to try three year old transplants of mango and *imli*.

12. Except *mahua*, all the accessory species reach heights up to 7 or 8 feet within one year in the nursery, if properly grown. Two year old transplants of these species are likely to become very unwieldly in handling.

13. In the case of species like *mahua* having a long tap root the transplanting of the stock is done from seed beds to the nursery lines at the end of the first year.

14. Nursery sowings are generally done from March to June but usually in May-June. In case of *nim*, *jamun*, mango and *mahua* sowings have to be deferred until the seeds

are ready in July. Regular weeding, watering and manuring in the nursery is essential in order to get good stock. The plants are pricked out in the nursery to suitable spacing at intervals. Pricking out is very essential and must be done in stages, progressively spacing the plants at 4 inches, 6 inches, 10 inches and 12 inches. Closely grown stock becomes lanky and is less vigorous and does not do well when planted out.

15. Transplanting in the baskets is started by the middle of May and finished by the end of June. *Santra* baskets, which are of 9 to 12 inches diameter and 18 inches deep are the cheapest and best for the purpose. Where such baskets are not available, wooden frame baskets or baskets of stems of *arhar* (*Cajanus indica*) can be made locally. Wooden frames can be used over and over again, but their handling is not so easy as the handling of plants in *Santra* baskets.

16. Plants are dug out with balls of earth $1\frac{1}{2}$ feet in length and about 10 inches in diameter and are carefully put into the baskets without disturbing the root system. It is most important that the lateral rootlets are least disturbed. Long tap roots are cut out with a sharp sickle to about 18 inches in length. More earth is added to fill the baskets compactly. These baskets are then arranged in a shallow trench which is given flow irrigation every morning or evening throughout the summer until they are transported for planting at the break of rains. Lack of adequate irrigation results in heavy mortality by *loo* and this must be guarded against. The trench is shaded throughout the summer. When the *loo* becomes too strong '*khas tattis*' have to be used to screen off the plants from the *loo*. As soon as the intensity of the *loo* decreases with the first shower of the monsoon the baskets are brought out in the open, in order to prepare the plants for the planting shock.

17. Manuring the plants in the baskets produces better results.

SOWING AND PLANTING

18. In the last week of June the soil is refilled in the trenches after breaking the clods. *Babul* is sown in two rings 6 inches apart with the outer ring 6 inches from the outer edge of the trench, the soil being raised 4 inches from the ground level. The sown seed should not be covered with more than $\frac{1}{2}$ inch layer of soil. Soaking of seed in cold water for four hours before sowing accelerates germination.

19. Early sowing of *babul* with soaked seed has a great advantage if there is no spell of drought after the first shower, as the growth of the seedlings is vigorous and they make an effective hedge by the end of the rainy season. If, unfortunately, the first shower is light and there is a spell of drought, early sowings may fail entirely, but as there is plenty of time for resowing and it is quite easy, the risk in early sowing is always worth taking.

20. The central pit is filled after the first shower of rain, but in no circumstances should the filling be done when the pit is full of water. Planting is done as soon as the monsoon is in full swing. The transplants are brought from the nursery in lorries and planted with baskets intact, if bamboo or grass baskets are used. The bottom of the baskets should, however, be removed. In case of wooden frame baskets, the frame should be very carefully removed so as not to disturb the tiny and delicate lateral roots.

21. Great care is essential in the handling of the baskets, right from the time of digging of the plants from the nursery till they are planted on the site. Slight shock to the basket will lead to casualty. The earthball should remain intact. Generally during loading and unloading the labour neglects these points and wholesale failure results. Manuring with calcium super phosphates gives very good results. A spoonful of calcium super phosphate or bone-meal is lightly mixed with the soil and sprinkled at the bottom of the planting pit before the plant is put in.

PURITY OF AVENUES

22. Purity is an important consideration for the beauty of roadside avenues. On aesthetic consideration, there should be homogeneity of species for fair lengths of the avenue. Trees should be symmetrically placed on both sides of the road and as far as possible they should have the same height. Two furlong unit is considered as the minimum for pure avenues and a 4 furlong unit the ideal. Monotony of the avenue is broken by change of species. Planting is planned accordingly. Keeping in mind the suitability of the soil and other locality factors, a planting map is prepared for the whole stretch of the avenue to be planted during the year. Transport of basket transplants is arranged according to this map. Otherwise, loading and unloading of the baskets becomes haphazard and wrong species brought to the spot. For mixed avenues with gaps, gap filling is done with the species predominant in the avenue so that the avenue may become progressively pure.

PROTECTION TECHNIQUE

23. Earlier, it has been stated that a live hedge of *babul* is sown before the avenue plant is put in. The object of raising this *babul* hedge is to protect the avenue plant from browsing. If properly treated, the hedge attains a height of about 2 to 3 feet at the end of the first rainy season. By the end of the second rainy season the hedge grows to a height of 5 to 6 feet and gives all the protection required by the avenue plant. Closely grown *babul* in two rings 6 inches apart, keeps away almost all animals from the avenue plant.

24. During the first year, the hedge itself has to be protected. Along with the *babul* sowings, branches from *babul* trees, *hins* (*Capparis horrida*), *karil* (*Capparis aphylla*), *reonj* (*Acacia leucophlœa*) are stuck into the loose soil on the outer periphery of the trench. These thorny branches are pressed outwards so that they do not overshadow the *babul* seedlings. Reinforcement of thorns from time to time is absolutely necessary as much of it is pinched by way-passers for fuel. To keep the thorns in proper position and for replacement from time to time, a *mali* is engaged for every 1½ or 2 miles of the avenue plantation. He keeps the fence effective and in addition does the weeding and hoeing of the *babul* hedge and the main plants, and watering, whenever necessary.

25. In built up areas and where thorns are not available barbed wire fencing with five or six strands of wire and wooden posts are used. Special care is necessary in built up areas as the fencing material is frequently stolen.

26. Effective protection of *babul* right from the time of sowing, timely weeding and cleaning are essential for making the *babul* hedge effective at the end of the second rainy season. At least two weedings of *babul* hedge are done in the first season, one immediately after germination and another in September. No weeding is necessary thereafter.

27. The main plant has always the danger of suppression by *babul*. This requires frequent attention. The hedge is kept trimmed to a height of 6 feet and all branches growing on the inner side are cut back at intervals.

TENDING AND PRUNING

28. The main plant is kept erect with the help of stakes. Watering is done immediately after planting, and whenever there is a spell of drought during the rains. Once the plant is established, no watering is necessary until the following summer. During summer watering is necessary particularly for mango and *jamun* which cannot be established without adequate watering for two or three years. During the winter frost tender plants like mango and *jamun* have to be protected. This is done by putting a grass cap over them. Before the growth starts in the next spring, a careful pruning of the lower branches is done.

29. The avenue plant is kept free from side and overhead shade. Weeding and hoeing of the soil is done from time to time according to necessity. This work is done by the *mali*.

30. In a forest plantation there is a regular competition between the plants to send up their leading shoots in order to reach the sun light as quickly as possible. As a result, there is a tendency in the plants for putting height growth. For want of sun light, the side branches are unable to grow and this results in natural pruning of the branches and the trees form clean straight boles. In contrast to this, a plant on the roadside avenue is without competition from other plants and is free to grow in all directions. Its side branches have the same chances of development as has the leading shoot and, therefore, the tendency is to develop a large crown and less height growth. Pruning, therefore, becomes necessary. In species like *imli*, *jamun*, etc., there is also the tendency to stagnate. With periodic pruning they start and continue to put in vigorous growth.

31. In the rains of 1950, the height growth of *imli*, and *jamun* plants planted on the Hamirpur Road and the Old Moghal Road in 1948 was equal to the height of plants planted on the Old Moghal Road in the year 1946. The former were pruned in the nursery before planting and then had two more prunings on the avenue, one in 1948 winter and another in 1949 winter. The latter had its first pruning in the winter of 1949. These 1946 plants were stagnating and frequent reinforcement of thorns was necessary for protecting them from browsing. These plants responded marvellously to pruning. During the 1950 spring they put in so much height growth as to make their crowns absolutely free from the reach of cattle and goats.

32. Pruning is done at successive stages, as below :—

(i) One pruning in the nursery during the winter season.

(ii) One pruning in the first year during the cold weather after the growth ceases and before it restarts again in the following spring.

(iii) One pruning in the second year at the same time as No. (ii) above.

Subsequent pruning would depend on the requirement of each individual plant. The aim should be get clean straight boles at least 10 feet in height and an umbrella shaped crown.

It should be emphasized that subordinates may develop a tendency to over-prune. Over pruning is bad and will make the plants lanky and they are likely to be broken or bent by the slightest wind. At least one third of the total height of the plant should be left untouched.

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INDIGENOUS CELLULOSIC RAW MATERIALS FOR THE PRODUCTION OF PULP, PAPER AND BOARD

PART VIII.—WRITING AND PRINTING PAPERS FROM *BOSWELLIA SERRATA*, ROXB. (*SALAI*)

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SUMMARY

Laboratory experiments carried out in this Institute on the production of bleached chemical pulp from *Boswellia serrata* (*salai*) are described. The results of pilot plant experiments are also included. Two samples of printing paper made from mixtures of *Boswellia serrata* pulp and bamboo pulp are appended. These experiments have shown that writing and printing papers with suitable strength properties can be prepared from *Boswellia serrata* using 25–40% of bamboo pulp in the furnish. As the chemical pulp from *Boswellia serrata* is short-fibred, it is essential to add bamboo or other long-fibred pulp to the furnish.

INTRODUCTION

Boswellia serrata, Roxb. (*salai*) is a moderate to large, branching, deciduous tree with a short bole of 12–15 feet in length or sometimes longer, if grown in fully stocked forests. The common girths met with are 4–5 feet although trees up to 8 feet in girth occur[1]. This species is common on dry hills throughout India where the rainfall varies from 20 to 50 inches and the temperature may rise up to 120°F. Commencing from the Sutlej, it follows the southern slopes of the Siwaliks of Ambala and Saharanpur and the lower hills eastwards to Nepal. It is common throughout the deciduous forests of Rajputana, Bihar, Madhya Pradesh, Bombay, Orissa, the Circars, Deccan and Carnatic, preferring the driest, hottest exposures and rocky hills, especially trap[2]. It is not found in Bengal, Assam, Burma or Ceylon.

This is an important forest tree, for it grows where others of greater commercial value refuse to thrive, and often occurs in pure stands over large extents, reproducing itself freely by seed, by coppice and by root suckers. *Salai* forms pure forests where the amount of iron in the soil becomes marked, as it is in the sandstone areas of Central India and in the Deccan

dry trap, e.g., Nimar forests in Madhya Pradesh and East Khandesh forests in Bombay State[1].

The sapwood of this tree is white but is very susceptible to fungal sap-stain which turns it greyish-brown ; the heartwood is yellowish-brown to dark greenish-brown[1]. While green the wood is heavily attacked by borer[3]. The wood is moderately hard. The weight of a cubic foot of this wood containing 12% moisture is about 36 lb.[1].

Since this wood is available in the vicinity of Sirpur Paper Mills Ltd., Hyderabad, an investigation on the production of chemical pulp suitable for writing and printing papers was undertaken in this Institute at their request. The results are recorded in this bulletin.

THE RAW MATERIAL

About 4 tons of debarked logs of *salai* wood were supplied by Sirpur Paper Mills Ltd., from Hyderabad. The supplies consisted of stem as well as branch wood. The logs were chipped in the factory chipper of this Institute and were sieved on the factory screen. The sieved chips were used for the experiments.

PROXIMATE CHEMICAL ANALYSIS

The chips were reduced to dust. The dust passing through 60 mesh and retained on 80 mesh was used for the proximate chemical analysis exploying the methods used at the Forest Products Laboratory, Madison, except in the case of pentosans where TAPPI standard T 223m-48 was used. The results of the proximate analysis are recorded in Table I.

TABLE I

Proximate chemical analysis of the wood of Boswellia serrata

		% on the oven-dry basis except moisture
1.	Moisture	10·2
2.	Ash	1·8
3.	Cold water solubility	6·3
4.	Hot water solubility	8·9
5.	1% NaOH solubility	15·5
6.	10% KOH solubility	32·8
7.	Ether solubility	0·7
8.	Alcohol-benzene solubility	4·3
9.	Pentosans	13·0
10.	Lignin	27·3
11.	Cellulose (Cross and Bevan)	50·7

From these results it will be seen that the cellulose content of this wood is satisfactory for its utilization for the production of paper pulp. The wood of *Boswellia serrata* is known to possess resin ; this is shown by the high value for the alcohol-benzene solubility.

FIBRE DIMENSIONS

The measurements of the length and diameter of the fibres from the chemical pulp from *Boswellia serrata* were made by the procedures usually followed in this laboratory. The

average fibre length of the pulp was found to be 0·88 mm., the minimum and maximum values being 0·60 mm. and 1·20 mm., respectively. The values for the fibre diameter varied from 0·0135 to 0·0385 mm., with an average of 0·024 mm. The ratio of the average fibre length to diameter was 37 : 1.

PRODUCTION OF PULP

A number of digestions were carried out on a laboratory scale by the sulphate process using caustic soda and sodium sulphide in the ratio of 2 : 1. Since the preliminary experiments showed that under-cooked pulps containing a number of shives were obtained when 18% of the total chemicals (on the air-dry weight of the raw material) was used for the digestion, and that the use of 22% of total chemicals led to the production of slightly over-cooked pulps, 20% of the total chemicals was employed in all the subsequent laboratory digestions. The temperature of the digestions was varied from 153° to 170°C. and the period of cooking from 4 to 7 hours. The cooking liquor was used at a concentration of 50 g./litre. In two experiments the chips were extracted with water prior to the digestion. The bleaching of pulp was carried out using bleaching powder in two stages with an intermediate alkali treatment. The first stage of the bleaching was carried out at 35°C. with about 75% of the total bleaching powder required, and the alkali treatment at 70°C. with 2% caustic soda on the basis of the air-dry pulp.

The digestions were carried out on the stem wood and branch wood separately and also on a mixture of these two in order to study the quality of the pulps from these two different parts of the tree. This was done in order to find out whether branch wood could be used for chemical pulping if the stem wood was used for some other purpose. The digestion conditions, bleach consumption, pulp yields, and strength properties of standard sheets made from bleached pulps after beating are recorded in Table II.

PILOT PLANT TRIALS

In order to confirm the results of the laboratory experiments regarding the suitability of the wood of *Boswellia serrata* for the production of bleached chemical pulps for writing and printing papers, three large scale experiments were carried out on the pilot plant of this Institute. A mixture of stem and branch wood was used. In each case about 1,000 lb. (air-dry) of chips were used, and the digestion was carried out by the sulphate process using 22% of total chemicals (on the basis of the air-dry chips) in a concentration of 50 g./litre at 162°C. for 6 hours. The yields of the unbleached and bleached pulps were 41·1% and 36·1% respectively, and the bleach consumption 10·2% of standard bleaching powder containing 35% available chlorine ; all these quantities are on the basis of the air-dry raw material containing 10% moisture. Experience has shown that a slightly larger quantity of chemicals is required for digestion on a larger scale than on a laboratory scale ; hence 22% of chemicals was used for the pilot plant trials against 20% employed in the case of the laboratory experiments recorded in Table II, although the preliminary laboratory experiments had yielded slightly over-cooked pulps with 22% of the chemicals. The pulp from one experiment was beaten, the requisite quantities of rosin size, alum and China clay were added, and used for making printing paper on the Fourdrinier machine of this Institute using 25% of bamboo bleached chemical pulp in the furnish. The pulp from another large scale experiment was used for another run of printing paper after mixing it with 40% of bleached bamboo pulp. The strength properties of these two papers are given in Table III. A sample each of these two printing papers is appended in this bulletin. The July 1951 issue of the *Indian Forester* was printed on the paper produced on the pilot plant of this Institute from a mixture of 75% *salai* pulp and 25% bamboo pulp.

TABLE II.—*Sulphate digestions of the wood of Boswellia*

DIGESTIONS CONDITIONS AND PULP YIELDS

1	2	3	4	5	6	7	8	9
Serial No.	Total chemicals* $NaOH : Na_2S = 2 : 1$	Concentration of chemicals	Digestion temperature	Digestion period	Consumption of chemicals*	Unbleached pulp yield*	Bleach consumption as standard bleaching powder containing 35% available chlorine*	Bleached pulp yield*
	%	g./litre	°C.	hours	%	%	%	%
1	20	50	162 for the first hour and 153 for the remaining period	6	18·8	46·8	10·3	42·3
2	20	50	,,	7	18·3	46·4	14·1	41·0
3	20	50	162	6	19·0	43·3	10·0	38·8
4	20	50	170	4	18·8	45·4	13·3	38·4
5	20	50	170	4	18·8	44·4	12·5	39·3
6	20	50	162 for the first hour and 153 for the remaining period	6	18·6	46·2	7·5	41·9
7	20	50	,,	7	17·4	45·7	7·6	42·0
8	20	50	,,	7	18·9	44·5	6·3	40·7
9	20	50	162	6	..	43·7	6·8	40·9
10	20	50	170	4	..	44·4	6·7	42·9
11	20	50	162 for the first hour and 153 for the remaining period	6	19·4	46·5	9·0	41·9
12	20	50	,,	6	18·5	44·7	7·2	41·9

* The % is expressed on the basis of the raw material (air-dry).

serrata and strength properties of standard sheets

STRENGTH PROPERTIES OF STANDARD SHEETS CONDITIONED AT 70% R.H. AND 82°F.

10	11	12	13	14	15	16	17
Freeness of pulp	Basis weight	Breaking length	Stretch	Tear factor (Marx-Elmendorf)	Burst factor (Mullen)	Folding endurance (Schopper)	REMARKS
c.c. (C.S.F.)	g./sq. metre	metres	%			double folds	
236	58·8	5820	3·3	66·4	28·7	140	In Serial Nos. 1–5 stem wood was used. In Serial No. 5 the chips were cooked in cold water for 48 hours prior to the digestion. In all these experiments well-cooked pulps were obtained. The bleach consumption was high in the case of pulps of Serial Nos. 2 and 4.
339	57·8	6260	2·3	61·0	23·2	50	
296	62·2	4720	2·7	52·5	25·3	400	
359	59·2	6250	2·9	60·8	26·9	50	
259	63·2	6230	2·8	55·8	26·7	90	
223	61·1	6390	3·9	65·9	39·1	510	In Serial Nos. 6–10 branch wood was used. In Serial No. 8 the chips were soaked in boiling water for 2 hours prior to the digestion. In all these experiments well-cooked pulps were obtained.
228	60·1	6700	2·8	71·1	39·7	280	
258	61·2	6790	2·5	71·9	38·7	220	
200	61·2	6070	3·9	65·3	37·7	310	
380	62·9	7630	2·3	82·6	36·4	170	
236	58·5	6670	4·3	65·4	34·3	210	A mixture of 75% stem wood and 25% branch wood was used. Well-cooked pulp was obtained.
236	59·4	5690	3·8	74·1	33·0	220	A mixture of 50% stem wood and 50% branch wood was used. Well-cooked pulp was obtained.

TABLE III

Strength properties of printing papers from Boswellia serrata (salai) (pilot plant trials)
The papers were conditioned at 65% R.H. and 84°F. before test.

Property	Printing paper from a mixture of 75% *salai* bleached pulp and 25% bamboo bleached pulp	Printing paper from a mixture of 60% *salai* bleached pulp and 40% bamboo bleached pulp
1. Freeness, c.c. (C.S.F.)	175	158
2. Ream weight in lb., 20″ × 30″—500 ..	26·4	27·6
3. Basis weight*, g./sq. metre ..	56·8	60·0
4. Thickness, mils (1/1000 inch) ..	3·85	3·10
5. Tensile strength (Schopper), kg. per cm. width		
(*a*) Machine direction	2·03	2·59
(*b*) Cross direction	1·02	1·23
6. Breaking length*, metres		
(*a*) Machine direction	3580	4320
(*b*) Cross direction	1800	2050
7. Stretch, %		
(*a*) Machine direction	1·7	2·0
(*b*) Cross direction	3·0	4·0
8. Tearing resistance (Marx-Elmendorf), g.		
(*a*) Machine direction	29	42
(*b*) Cross direction	33	46
9. Tear factor*		
(*a*) Machine direction	51·1	70·0
(*b*) Cross direction	58·1	76·7
10. Bursting strength (Ashcroft), lb./sq. inch	10·9	15·1
11. Burst factor*	13·5	17·7
12. Folding endurance, double folds		
(*a*) Machine direction	8	21
(*b*) Cross direction	3	10

* For calculating this, oven-dry weight of the paper was used.

DISCUSSION

It will be seen from the results recorded in Table II that chemical pulps suitable for the production of writing and printing papers can be prepared from *Boswellia serrata* by the sulphate process. Stem wood and branch wood can be used either alone or as a mixture. The consumption of bleaching powder is less in the case of branch wood than stem wood. On the whole, the pulps from the branch wood have higher strength properties than those from the stem wood. The extraction of the chips with water prior to digestion helps in lowering slightly the bleach consumption. Since the chemical pulps from this wood are short-fibred, it is essential to admix these with long-fibred pulps such as bamboo or sabai grass pulps.

PRINTING PAPER

made from a mixture of 75% *Boswellia serrata* pulp and 25% bamboo pulp

PRINTING PAPER

made from a mixture of 60% *Boswellia serrata* pulp and 40% bamboo pulp

The results of the pilot plant experiments show that writing and printing papers with satisfactory strength properties can be made by admixing *salai* bleached pulp with 25–40% of bamboo bleached chemical pulp.

CONCLUSIONS

1. Bleached chemical pulps suitable for the production of writing and printing papers can be prepared from *Boswellia serrata* by the sulphate process using either stem or branch wood or a mixture of the two.

2. Since the pulps from the wood of this species are short-fibred, it is essential to mix these pulps with 25–40% of bamboo or other long-fibred pulp for the manufacture of writing and printing papers.

Thanks are due to Sirpur Paper Mills Ltd., Hyderabad, for the supply of *salai* wood free of cost for this investigation.

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MORUS LÆVIGATA, WALL.

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A fine tree reaching a height of 100 feet or more and a girth of 15 feet in the eastern Himalayan zone, but smaller dimensions in the western Himalayan zone (1). In older trees the bark is dark coloured, rough and furrowed and, when cut, it shows fine streaks of grey and white (2). This is the common Mulberry of Bengal, Assam and Upper Burma. It is a native of the tropical and sub-tropical Himalaya, from Indus to Assam (Khasi Hills), both wild and cultivated. It extends from Kumaon eastwards, through Bengal and Assam to Burma, where it occurs in the Shan States, Martaban and Tennaserim hills, in tropical forests (3). Rodger calls it a medium sized tree of the valley forests of Burma (4), It also occurs in the Greater Andaman and adjoining islands. It is cultivated in Bihar and as far north as Lahore (5) (6). The tree yields an excellent timber, good for outdoor use as it stands weather. It is suitable for low grade plywood.

Local names.—*Tūt* (Hindi) ; *kimbu* (Nepalese) ; *tūt, shah-tūt, siyah-tūt* (Kumaon) ; *tūt* (Punjab) ; *nambyong* (Lepcha) ; *singtok, senta* (Bhutan) ; *bola* (Assamese) ; *nam-byong* (Bengali) ; *malaing, tapwisa, tawposa, taungposa, posa* (Kachin) ; *labri* (Chindwin) ; *tawp-wesa, ma-lainpen* (Burman).

Botanical description (7).—Shoots, stipules and peduncles softly hairy. *Leaves* 3–7 inches, with 3 to 5 basal nerves, undivided or occasionally lobed (Kurz), membranous, young sparsely pubescent or densely pubescent soon turning glabrous (Kurz), base rounded or cordate, ovate acuminate, finely serrate (Brandis), petiole 1–1½ inches, pubescent, stipules linear-subulate, pubescent (Kurz), *Spikes* : male 4–5 inches, slender, villous, shortly peduncled ; female as long, and very similar to the males but the flowers more crowded and glabrous or nearly so ; *sepals* 4, rounded, concave of male, very hairy of female, glabrous (sepals of female thin, the 2 inner flat, the 2 outer keeled, Brandis) ; *Ovary*—compound, oblique, styles nearly free, papillose from the base (glabrous, Brandis) ; *Fruit*—long-cylindric, yellowish-white, sweet (incipid, Brandis), very small.

Distribution and Habitat.—The natural home of the tree in India is the sub-Himalayan belt from Kumaon eastwards to Assam up to 5,000 feet in the hills (Fig. 1) ; beyond India the tree extends into Burma, spreading out over a wide zone in the Shan hills and southwards into Martaban and Tennaserim hills (evergreen forests of Taungyin, Brandis) and extending further down across the Bay of Bengal to the Andamans. It has also been more or less widely cultivated in the Indian sub-continent from Punjab (Pakistan) in the west through Bihar, Bengal, Assam to Burma.

In Bengal it grows from the foot-hills up to 5,000 feet and occurs in the plains sporadically on silt, but its best growth is found in the hills from 2,000 to 4,000 feet. Its natural regeneration is seldom found in the forests (8). In the Darjeeling division (9) the tree occurs in the "Valley forests" which occupy elevational ranges from 600 to 3,000 feet and is generally found only in pockets or in northerly aspects where the vegetation is miscellaneous in character and where its chief valuable associates are, *Michelia champaca, Terminalia myriocarpa, Ailanthus grandis, Bombax malabaricum, Duabanga sonneratioides, Tetrameles nudiflora, Gmelina arborea, Spondias axillaris, Acrocarpus fraxinifolius* and, etc., together with *Terminalia crenulata, T. belerica, Garuga pinnata*, etc. The tree has also been raised here in plantations. In the Kalimpong division (10), the tree is found in the "Lower Hill forests" between 300 to 3,500 feet elevation where the crop is of the mixed-dry type with occasional

patches of the mixed-wet type. Sal occurs here as isolated trees and among the other common tree species are *Garuga pinnata*, *Sterospermum chelonoides*, *Eugenia formosa*, *Schima wallichii* and others.

FIG. 1—Distribution of *Morus lævigata*, Wall.

The tree is found in practically all the forest divisions of Assam, from the plains up to 5,000 feet in the hills, but is generally sporadic except in Sadiya division where it is fairly abundant (11). It occurs in both the evergreen and mixed deciduous forests, the latter sometimes of the open type. In Sadiya division (12) the tree occurs in the "Hollock",

"Miscellaneous"—and "Open" types of forests ; in the first type its associates are *Mesua ferrea, Amoora wallichii, Cedrela toona, Chikrassia tabularis, Dyroxylum hamiltonii* and sometimes *Michelia champaca* and *M. oblonga*. In the "Miscellaneous" type the principal species are *Mesua ferrea, Altingia excelsa, Dipterocarpus macrocarpus, Cinnamomum cecidodaphne, Chikrassia tabularis, Terminalia myriocarpa, Albizzia lucida, Michelia oblonga* and *M. champaca*. In the "Open" type, which is found as scattered patches within the other two types ; occasional trees of *Terminalia myriocarpa, Albizzia lucida, Cedrela toona, Gmelina arborea, Bombax malabaricum* and *Michelia oblonga* are found along with *Morus lævigata*. In the Lakhimpur and Sibsagar divisions (13) Eastern Circle, the tree is one of the important auxiliary species of importance and occurs sporadically in the evergreen forests, in which the principal species occurring are *Dipterocarpus pilosus, Shorea assamica, Mesua ferrea, Altingia excelsa* and *Castonopsis* spp. Of these the first tree forms the principal component of the upper storey of the giant evergreen forest type. The natural regeneration of the species is stated to be rare. In the plains reserves on the south bank of Brahmputhra river, Lakhimpur division (14), the tree is found in mixed-deciduous forests containing in places evergreen patches in the Jokai, Telpain, Namdang and Dehingmukh forest reserves, where the forest crop is of the "*Nohor* type" and is characterized by the predominance of *Mesua ferrea* (*nohor*). The area covered by forests of this type contains very well drained high land which is not inundated during the annual floods except in years when these are exceptionally high. The principal associates of *nohor* in these forests are *Altingia excelsa, Dillenia indica* and *Bischofia javanica*. *Morus lævigata* is sporadically distributed and forms less than 1 per cent of the crop in such forest. In the Kamrup sal forests, Western Circle (15), the tree occurs in the "hill type" and "plains type" sal forests as well as in "mixed-deciduous" forests generally in places where only miscellaneous species are found. Among the associates of *Morus lævigata* here, are *Adina cordifolia, Cinnamomum cecidodaphne, Artocarpus chaplasha, Bombax malabaricum, Cedrela toona, Schima wallichii, Lagerstrœmia flos-reginæ, Lagerstrœmia parviflora, Albizzia procera, Trewia nudiflora, Duabanga sonneratioides, Cassia fistula, Michelia champaka* and others. In Goalpara division, Western Circle (16), the tree occurs in riverain silt forest, i.e., forest growing upon silt deposited by the rivers, which is found where the water-level is not deep and on which *Acacia catechu* and *Dalbergia sissoo* have not yet colonized. Here it is mainly associated with *Trewia nudiflora, Bischofia javanica* and a few *Dillenia indica* and other species. Apart from *Morus lævigata*, others like *Cedrela toona* and *Gmelina arborea* are said to do well here. In the Darrang forest division (17), the tree occurs in the forest type described as "*bonsum* forest" and "mixed evergreen forest". In the former type *Phœbe goalparensis* (*bonsum*) predominates and is found from the western boundary of Khalingudun reserve in the west in discontinuous patches to the Gabru River in the east with a small, outlying patch in the Naduar reserve. The principal associates of *bonsum* in such forests are *Tetrameles nudiflora, Ficus bengalensis, Ailanthus grandis*, and occasionally *Bombax malabaricum* which generally towers above the *bonsum* and forms the topmost storey. *Morus lævigata* and *Michelia oblonga* occur rarely in these forests. In the latter type, i.e., mixed-evergreen forests, to which by far the greater proportion of the forests of the Darrang division belong, *Morus lævigata* occurs generally sporadically and some distance away but not very far from streams. A rather gregarious patch of the species, however, occurs on the east bank of the Borgang near Dikhalmukh, while numerous fine stems are found along the west bank of the Bhoreli.

In Burma the species is found in the valley forests of the Shan States, Martaban and Tennaserim hills, generally in the evergreen type of forest. In West-Katha forest division the tree occurs in the evergreen forest which covers all the higher hills and ridges on the Meza watershed, forming part of the Mezbya reserve and portions of the Nanhin and Kalat reserves near the source of the Meza. It also occurs in portions of the Mankat, Manmaw, Mawhun and Petsut reserves. The characteristic species here are *Shorea assamica, Morus lævigata,*

Saraca indica, Dipterocarpus turbinatus, Acrocarpus fraxinifolius, Macaranga spp. with *Trewia nudiflora* and *Ficus glomerata* along streams. In the Mohnyin forest reserve of Katha forest division (19) the tree grows well in the evergreen forests at the foot of the hills along with others like *Michelia champaca, Bischofia javanica, Cedrela toona, C. microcarpa, Chikrassia tabularis, Dipterocarpus turbinatus, Disoxylum binectiferum* and *Protium serratum*. In Myitkina forest division, Northern Circle (20), the tree is a native of the evergreen forests whose characteristic species are *Dipterocarpus turbinatus, Shorea assamica, Cedrela toona, Acrocarpus fraxinifolius, Macaranga* spp., *Tetrameles nudiflora, Disoxylum binectiferum* with *Trewia nudiflora* and *Ficus glomerata* along streams. Teak is also frequently found here.

In the Andamans the tree is found in the greater Andaman and the adjoining islands and here attains heights of 40 to 60 feet and girths of 4 to 7 feet (4).

Geology, Rock and Soil.—Morus lævigata grows on a variety of geological formations, but most commonly on gneiss and sandstone series, though found frequently also on schists, slates, quartz, quartzite, limestone, phyllite and others. It thrives best on well drained high land alluvial soil, but also grows upon silt deposited by rivers which have risen above the annual flood level or, at higher elevations on soils of a clayey texture. It can thrive on alluvium, both acid and alkaline in reaction.

In Bengal it thrives sporadically on silt in the plains (8). In Assam it occurs most abundantly on light alluvial silt in the plains of the Sadiya frontier tract, where it is observed to spring up in clumps on newly cleared areas (21). In the Darjeeling division (9) the underlying rock is true gneiss, the geological series being those of the Sikkim and the Daling but the rock very frequently passes into mica schist or into a felspathic mica schist or gneissose schist. The soil found within the forests is almost entirely the result of decomposition of gneissose rocks, lacking in lime. The underlying soil is generally reddish and of a clayey texture, and is covered by a fairly deep layer rich in humus. Along the Tista and Rangit river valleys areas of recent alluvial soil are found. Plantations of *Morus lævigata* have been raised in the latter valley with success. In Kalimpong division (10) the underlying rock is Sikkim-gneiss which gives, on decomposition, a light-brown clay which, though well adopted for the growth of certain types of forest when mixed with humus, is not quite suitable for sal. In Sadiya division (12), where *Morus lævigata* is most abundant in Assam State, the soil is almost entirely alluvial. The underlying rocks of the surrounding Aber–Miju and Patkai hills, from which this alluvial soil has probably been washed down and redeposited, consist of metamorphic rocks of various kinds such as schists, slates, quartzites and quartz schists, phyllites, brecciated limestones, dolomites, garnet-hornblende and gneiss. According to their source the alluvial soils have been classified as those of the Brahmputhra alluvium and those of the Daling alluvium of which the former is alkaline and the latter acid in reaction. In the Lakhimpur and Sibsagar divisions (13), the underlying rock consists of sandstone of the true Tipam series type occurring with grey shales. The soil is mostly recent alluvium composed of a mixture of sand and clay usually forming in the foot-hill areas a good quality sandy loam. In the plains reserves on the south bank of the Brahmaputhra River, Lakhimpur division (14), the tree grows on the vast alluvial plain formed by the rivers Brahmaputhra, Burhi Daling and Noa Daling. The Brahmaputhra coming from the Himalayas and the Daling from the Patkai hills, have deposited soils of different kinds. The former have a surface layer of silty loam varying in depth from 1 to 3 feet with characteristic grey colour. The Daling alluvium is generally a loam of considerable depth and the colour varies from reddish to yellowish. This is due to the fact that the Himalayas, which form the parent of the Brahmaputhra alluvium, are formed of a massive, crystalline and metamorphic core while the Patkai hills have an apparent core of slates and sandstones overlain by an immense deposit of upper tertiary sandstone. In the Kamrup sal forests (22), the principal rock is gneiss, which has been metamorphosed by intruded igneous rock, evidenced by the out-crops of pure

quartz which frequently occur. In some areas thick beds of conglomerate are formed at the foot of the hills. A rather gritty shallow soil formed by the weathering of the metamorphosed rocks is found on the crests and upper slopes of the foot-hills. The lower slopes of the foot-hills have very deep red fertile clay probably of lateritic origin. In the plains the soil is generally deep alluvium consisting of sandy loam with very few rocks; in some cases, adjoining streams, the alluvium becomes definitely clayey. In the *bonsum* (*Phœbe goalparensis*) forests of Darrang division (17), where *Morus lævigata* occurs, the soil is alluvial in origin and of considerable depth and well drained. In certain places (Charduar and Naduar reserves) more or less well defined *bhabar* formation is noticeable towards the foot of the hills, the sub-soil consisting of coarse water-borne pebbles, mainly of quartzose and schistose origin; superimposed on this layer is a layer of sandy loam of varying depth and over it again a layer of humus. In Goalpara division (16) the soil consists of the coarse water-borne debris of the Himalayas which contains various strata showing bands of coarse sand with or without an admixture of clay and rounded water-worn stones varying in size from pebbles to the largest boulders. The stones are mostly quartzose rocks and schists, but granites and gneisses are also present; this is typical of *bhabar* country; here the soil is physically and physiologically dry except in depressions where clay has collected, forming a stratum impermeable to the surface water. In the *tarai*, bands of underlying yellow clay bring the water eventually up to ground level; there is also a certain amount of clay and silt in these areas which is absent in the *bhabar*.

In Burma, sandstones predominate in the areas where *Morus lævigata* is found. In the West Katha division (18) the hills are formed of sandstones and limestones with frequent granitic and metamorphic intrusions. The soils consist of from almost pure sand in the valleys to a stiff clay. On the hills are generally found clayey loams derived from the metamorphosed rocks. In Myitkina division also the hills are formed, for the most part, of sandstones of the upper tertiary period with frequent granite and metamorphic intrusions. The soil on the hill-side is generally sandy loam, but in the plains and valleys it is frequently alluvial. Laterite covers large areas in the Irrawady valley.

Climate.—In the normal habitat of *Morus lævigata* the climate in the plains is generally tropical, though not of the severe kind with a summer maximum shade temperature perhaps not exceeding 100°F. and a winter minimum not going below 40°F. In the hills, however, frost is not uncommon, the climate being sub-tropical. Great variations of rainfall are encountered in the area, from a little over 60 inches in Kamrup sal forests (Assam) to well above 200 inches in Sadiya division. The climate is noted for its humidity which is very high in the rainy season—June to October—when it approaches the saturation point, while it is fairly low in the dry summer months, being about 60 per cent.

Leaf-shedding, Flowering and Fruiting.—The tree is generally leafless during the hot season in the Andamans (4). The flowers appear in spikes in March (Burma), March–April (Andamans), when the tree is leafless (Parkinson). The fruit, which ripens from April to June, is long cylindrical, rather dry, pale-yellow when ripe. In the duars the seed is not always fertile; Troup (23) says that it is possible that such seeds may have been collected from dioecious female trees which have not been fertilized.

Seed.—Description, time and method of collection, storage and viability, etc. The seed is minute, about the size of mustard. Seed-weights have been differently recorded by different authorities. At the Forest Research Institute, Dehra Dun, the weight was 12,400 seeds per oz. Homfray has given the weight of Bengal seed as 13,000 per oz. (8), while Sen Gupta has recorded it at 12,300 per oz. The same author has recorded the weight of seed from Assam as 6,100 per oz., while De (10) has given the weight of Assam seed to be 2,500 per tola (6,250 per oz.).

Seed years are irregular, and all trees do not produce fertile seed. In Bengal 1919–20 was a total failure year (24), 1920–21 was a good seed year (25) though there was no natural regeneration as the seedlings were destroyed by game, but 1922–23 was again a poor year (26). The seed time is first half of April to second half of May in Bengal (8) (May and June, E. O. Shebbeare) and April–May in Assam (11).

In Bengal the fruits are collected from trees known to be fertile, by lopping small branches containing clusters of fruits. They are heaped in the shade and allowed to rot for 5 to 6 days, then washed in water and the small seeds separated by hand and dried in the sun. The seed can be preserved in a dry ventilated shed till May–June. In Assam ripe fruits are collected from trees, allowed to rot for a few days after which the pulp is rubbed off with the hand in a bucket of water. The seeds are then dried in shade and sown in open nursery-beds. Rowbotham has recommended that the fruits should be collected from the ground and spread out in the sun for a few days to complete ripening if necessary. The minute seeds should then be separated from the pulpy mulberry fruit by washing in a shallow vessel of cold water and spread out to dry on a mat in a cool, dry place.

The seeds do not store for a long time (27). C. G. M. Macarness (12) has reported that in Lakhimpur and Sibsagar divisions the seed has been observed (in Sadiya) to germinate after being a year in the soil and following the burning of clearfelled jungle, but this has not been confirmed by any other observer.

The seed germinates satisfactorily, the viability being 50 to 60 per cent. At the Forest Research Institute, Dehra Dun, 80 per cent germination was observed for Bengal seed but 1 per cent only for Assam seed (28). In Bengal 60 per cent germination was obtained in about 5 weeks (fortnight to a month, E. O. Shebbeare). In Assam its germination is described as "good, up to 50 per cent". On heavy soils germination is said to be low, the best results recorded having been 10 per cent (21). In Lakhimpur and Sibsagar divisions germination is stated to have been very disappointing on loam soil being a maximum of 1 per cent. C. J. Rowbotham has stated that in nature, except in the most favourable soil (alluvial silt), the germination of *Morus lævigata* does not seem to be very good. He obtained good germination by treating the seed for 3 to 4 hours with dilute hydrochloric acid, while at the same time untreated seed did not germinate at all. In the experimental nurseries of Jokai and Hollangpur reserves, Assam, germination was also found to be very disappointing in loamy soils being a maximum of 1 per cent (13).

Silvicultural characters.—*Morus lævigata* is a light demanding tree which, on favourable soils, is capable of very rapid growth. It is a tree of the moist localities, generally thriving best in evergreen forests. It prefers a well drained, light alluvial soil and loves the light alluvial silt of the plains (Saidya frontier tract of Assam) where its growth is phenomenal reaching 10 to 20 feet in the first year, and it also grows rapidly (10 feet or so per year) in after years. If grown scattered or along with slower growing species it throws out numerous branches and several whippy leading shoots after the first year or two. It is, therefore, best to grow it close as a pure crop or with one of its local associates which grow equally rapidly, e.g., *Kydia calycina* (21). It is easy to raise artificially by sowing or planting, and should lend itself also to vegetative propagation by means of branch cuttings. It coppices and pollards satisfactorily. It is very susceptible to damage by game, especially deer, and where there is game its plantations will have to be fenced in the first two years to ensure success. It is fairly frost resistant, but is killed by fire (15). Being a light demanding species its regeneration in forests is generally insufficient under cover but its seedlings are reported to come up naturally in clearings made in the forest or along timber dragging paths where the mineral soil lies exposed.

Artificial regeneration.—The species is easy to raise by direct sowing, either broadcast or in lines, with or without the aid of field crops and this method has been successfully practised in all the areas. Rowbotham (Assam) says that the species is best sown direct early in May, broadcast, in lines 6 feet or 8 feet wide, as its extremely rapid growth on favourable soil makes it difficult to transplant later on (29). Owing to its fibrous root system which is easy to handle its transplanting is easy, and success by this method has been reported from Bengal, Assam and Burma. The species can also be stump-planted. E. O. Shebbeare says that plants kept in nursery beds through the cold weather and planted after pruning root and shoot early in the following rain send up one or more whippy shoots at first of which one stiffens up subsequently to form the tree (30). Plants for transplanting can be raised by sowing the seed in nursery bed as soon as possible after collection, as the seeds rapidly lose their viability. The tiny seed is sown broadcast in the beds about the end of May (Assam). As the seed is minute some sand can be mixed with the seed to facilitate the sowing. In Bengal, at higher elevations, the seeds are sown broadcast in shaded nursery beds as soon after seed collection as possible. At lower elevations, the seeds are pricked out 4 × 4 inches into shaded beds as soon as they are big enough to handle ; and if sowing has been done immediately after seed collection the plants will be big enough to transplant by August. At higher elevations the plants will have to be kept till the second year rains (8). Sowing the seed in nursery beds in March has been recommended by some, and this can be attempted if fresh ripe seed is available, which is not usually the case as the seed generally ripens from April onwards. It is best to sow fresh seed soon after collection.

The young plants can be put out straight from the seed beds when they are about 4 inches high or lined out 6 × 6 inches and allowed to remain till the next rains, when they can be transplanted, however large, after root and shoot pruning or by stripping the leaves off (31).

In Bengal, at lower elevations, the plants are transplanted 6 × 6 feet entire with a handful of earth round the roots in August of the first rains. Winter transplanting in the first cold weather and stump planting of second year plants is also done. At higher elevations, second year seedlings are transplanted during rains with balls of earth at 6 × 6 feet, and winter transplanting first year seedlings with balls of earth at an elevation of 5,000 feet is stated to have given cent per cent success (8). Success with winter transplanting entire seedlings (without balls of earth) of the first year after stripping their leaves has also been reported (25).

In Assam, Bor has recommended the transplanting of nursery raised first year seedlings (15). Similarly, in Sadiya division, planting of the species along with *Terminalia myriocarpa* (*hollock*) has been prescribed by Purakayastha (12), for the '*hollock*', 'miscellaneous', and 'open' forests.

In Burma, in Bilumyo reserve, Myitkina division, *Morus lævigata* transplanted at 3 × 3 feet espacement over an area of 2 acres in 1918 grew vigorously and attained a height of 45 feet and girth of 18 inches in 9 years.

In Assam, on account of the ease with which the species can be propagated by sowing and its rapid growth, direct sowing, pure or mixed, has been generally practised, although planting stumps and transplanting with balls of earth have also been tried with success. Very satisfactory results have been obtained with sowing in several divisions, notably Darrang division, provided this operation is restricted to localities where there is little danger from deer damage. Here sowing is done, in lines 2 feet wide and 6 feet apart, at the break of the rains. In Sadiya division sowing in cleared lines gave satisfactory results, the chief species sown being *Terminalia myriocarpa*, *Cedrela* spp., *Chukrassia tabularis*, *Albizzia lucida*, *Morus lævigata* and *Duabanga sonneratioides* (32).

Reports of success in sowings from various localities have been uniformly good. In Jokai reserve, Lakhimpur division, Assam, sowings of *Morus lævigata* done in 1925 and inspected in March 1926 showed fair success and the plants were 9 inches high. In Ramparshad plantation, Cachar division, plants from sowings done in 1924 had attained heights of 12 feet by 1926 (Fig. 2), but had been badly browsed by game. In the Dikring regeneration area, Sadiya division, 8 feet strips in a cleared and burnt area first sown with *hollock* (*Terminalia myriocarpa*) and later on *Morus lævigata* sown in patches at stakes 10 to 15 feet apart in the midst of *hollock* gave completely successful results, and the plants were 6 to 10 feet high by March 1926. In another place called Nongaon, line sowings done in 1921 of *Duabanga sonneratioides*, *Artocarpus chaplasha*, *Morus lævigata*, *Kydia calycina* and *Terminalia myriocarpa* after completely clearing the forest had attained heights of 40 feet, 12 feet, 18 feet, 30 feet and 15 feet respectively by 2nd March 1926. Cleanings were done by forest guards. Similar sowings done under forest canopy on mounds 30 feet by 10 feet and on patches about 50 per acre were swamped by weeds. The bad effects of keeping too much overhead cover is stated to have caused this. These results indicate that regeneration by mixed sowings in lines is practicable with *Morus lævigata*, provided the overhead forest cover is completely removed. Sowing whole line is stated to be better than sowing in patches in the lines. Sowing three rows of seed in the lines is also said to be better than broadcast sowing in lines ; if the area can be properly cleared, it is recommended to make 4 feet strips at say 12 feet from centre to centre with 2 or 3 lines of seed in each strip. When seedlings are overdense thinning out by hand at the end of the first season to 6 × 6 inches has been advocated. Cleanings must be continued till really necessary as the grass *Saccharum arundinaceum* has been seen to come up in the lines.

FIG. 2—*Morus lævigata*, Wall. Sown in clumps at stake, Dhalai beat, Cachar division, Assam.
(*from the Photo collections of the Central Silviculturist, F.R.I.*).

Regeneration of Morus lævigata along with field crops, Taungya.—*Morus lævigata* can be raised along with field crops, and this method has become increasingly popular in recent years.

In Bengal, the foot-hill country up to about 3,000 feet is the area in which the fastest growth occurs and *taungya* here is easy. The species most commonly grown here are *Morus lævigata*, *Duabanga sonneratioides*, *Terminalia myriocarpa*, *Acrocarpus fraxinifolius*, *Cedrela* spp., and *Chukrassia tabularis*. Fencing has to be done in the plains as without it deer and bison will exterminate most species other than sal. In the divisions Kalimpong (Tea Gardens Long Rotation W.C.) and Darjeeling (Rangit Valley W.C.) (33) clear-felling and artificial regeneration with the aid of *taungya* has been prescribed by the current working plans for raising this species. In Sadiya division, Assam, 4 miles from a place called Sarkhoa, it is reported that the political agent got seeds of *Morus lævigata* and *Bombax malabaricum* sown among field crops. These trees attained heights of 30 to 35 feet in 6 years and stood in groups amidst cultivation. Similarly, in Mohnyin reserve forest, Katha division, Burma, regeneration of the species by *taungya* by sowing seed has shown promising success (18).

Mixture of species.—The species has been raised by sowing either pure or in mixture. Mixed line sowings with *Kydia calycina* is recommended in Lakhimpur and Sibsagar divisions (12). Owing to its rapid growth and tendency to branch when 20 to 30 feet high Rowbotham has recommended its being grown pure and close together (29). If grown with a species which is not adequately fast growing *Morus lævigata*, being a fast growing species, is likely to develop very branchy boles. Its growth along with another species, nearly equally fast growing, like *Kydia calycina* is deemed advantageous (27).

In Bengal pure plantations are considered to be silviculturally unsound for this species (8). The method in the plains and foot-hills is to mix a handful of *Morus lævigata* seed in a bag of *Chikrassia tabularis* and *Terminalia myriocarpa* seeds and to sow in lines. The tree comes up widely scattered in the lines and looks healthy and, being a faster grower than the other two species, its bole is kept clean by them.

Tending.—As the species is fast growing and rises above the general level of weed growth in the very first year no weeding may be required after the second year or in some cases even after the first year. If sown in lines congestion among its seedlings must be removed by spacing the seedlings out 6 × 6 inches. In a well stocked plantation thinnings will be required from the 5th year. In Assam, thinnings are required from the 5th year in plantations spaced 8 by 8 feet. In the Darjeeling forest division the necessity or otherwise of weedings is stated to depend upon the intensity of browsing damage by deer and, provided plantations are fenced successfully from deer, no weedings are considered necessary after the first year. Thinnings have been prescribed in the 7th and 12th year for crops raised by broadcast-sowing in strips. In Sadiya forest division the following tending operations are prescribed for plantations : 2 rains weedings in the 2nd year, one in the 3rd year, climber-cutting in the 4th year, a D-grade thinning each in the 5th and 8th years, followed by a C-grade thinning each in the 12th and 20th years, and two more B-grade thinnings in the 30th and 40th years.

External dangers and protection.—*Morus lævigata* is very susceptible to browsing damage by wild animals, especially deer and bison. Success or otherwise of its regeneration will, therefore, depend upon the degree of protection which is given to it in the first one or two years, until the plants rise above the level of this damage. In places where deer, etc., abound it may not be possible to raise this species without effective fencing and in the Darrang division, Assam, its regeneration has therefore been restricted to localities where there is little danger of this damage. In Bengal, also, the species cannot be raised in the plains without effective

fencing as, without it, deer and bison exterminate it. In this State young trees 5 years old have often been found to be attacked by larva of longicorn beetle. In Myitkyina forest division, Burma, the species is reported to be attacked by a Lamiid—*Apriona*.

Methods of management.—Among the principal species which decide the system of management in the forests where *Morus lævigata* is found are *Terminalia myriocarpa*, *Phœbe hynesiana* and sal. According to the nature of the forest growth such forests are managed under the selection system, followed or not by compensatory plantations, and the clear-felling system accompanied by artificial regeneration by sowing or planting, with or without the aid of *taungya*. In Bengal, in the Kalimpong and Darjeeling divisions, the introduction of *Morus lævigata* by planting seedlings in *taungya* after clear-felling the natural forest is prescribed; *taungya* here is easy in the foot-hill country up to about 3,000 feet and the growth of the tree is also rapid here. In Burma, too, regeneration of the species by *taungya* has been prescribed in the Mohnyin reserve of Katha forest division (19).

In Sadiya division, Assam, the method of management of the *hollock* (*Terminalia myriocarpa*), miscellaneous and open forest is selection fellings, with compensatory regeneration, in which it is prescribed that *Morus lævigata* should be planted with *hollock* in mixture. The exploitable girth for *Morus lævigata* has been fixed at 6 feet in the Veneer Wood working circle and 7 feet 6 inches in the Local Trade working circle. For the Firewood working circle clear-felling and artificial regeneration under a rotation of 80 years is prescribed for the hardwoods among which this is one (12). According to the current working plan for the above division the regeneration of the species in the Local Trade and the Firewood working circles should be done on flat land by direct sowing of the seed in strips 2 feet wide and 8 feet apart from centre to centre; on areas covered with small mounds formed of earthworm casts, all such mounds should be sown without any attempt at regularity. The species should be attempted only in high level areas and not in low lying ones. In the Kamrup sal forests, Bor has prescribed selection system with an exploitable diameter of 18 inches in the Hill sal—and Miscellaneous working circles (15), and the same system with an exploitable girth of 6 feet has been prescribed by Purakayastha for the Lakhimpur division plains forests which lie on the south bank of Brahmaputhra river. In Lakhimpur and Sibsagar divisions, again, the tree is worked under "provisional fellings of the selection type" (13). In Myitkina forest division, Burma (20), selection system with improvement fellings has been applied. In West Katha forest division also the tree is worked under the selection system with an exploitable girth of 6 feet.

Statistical.—The rate of growth of *Morus lævigata* in plantations is often very rapid in the first year in suitable localities and remains the same also in the next few years. In the Tista valley range, Darjeeling division, Bengal, the average rate of height growth is as follows :—1st year—7 feet ; 2nd year—9 feet ; 3rd year—12 feet ; 4th year—15 feet ; 5th year—18 feet. At an elevation of 5,500 feet : 1st year—1 foot ; 2nd year—2 feet 9 inches (8). At Sukna (altitude 550 feet, rainfall 148 ·8 inches) planted in 1934, the trees attained an average height of 27 feet and a girth of 1 foot 3 inches in 7 years. In Assam its rate of growth has been described as very fast, one year old seedlings having attained a height of 10 feet. On the light alluvial silt soil of the plains in the Sadiya frontier tract its growth is said to be phenomenal being 10 to 20 feet in the first year and 10 feet or so in after years. In Sadiya forest division *Morus lævigata* sown among field crops attained a height of 30 to 35 feet in 6 years. In Cachar division near Dalai forest rest-house, sown in 1924 the plants attained a height of 12 feet by March 1926. In the same division, in sample plot No. 3 of *Morus lævigata* plantation of 1927–28, the trees had attained an average height of 72 feet 2 inches and a girth 23 ·8 inches (1945) giving a rate of mean girth increment of 1 ·4 inches per year. Between 1940 and 1945 (5 years) the average increment in height of dominant trees was 11 ·43 feet

and increment in girth was 5·91 inches, which gives an annual girth increment of 1·18 inches. Its rate of growth in Burma is also rapid; transplants of 1918 made in Bilumyo Reserve, Myitkina division, attained a height of 45 feet and girth of 18 inches by January 1927. The rate of growth of the tree, according to Gamble, is moderate, averaging 7 rings per inch of radius which gives a mean annual girth increment of 0·9 inches (1).

Yield.—From Bengal the supplies of the timber of *Morus lævigata* are stated to be fair, and in Assam large quantities are said to be available in Goalpara, Kamrup and the North-East frontier divisions. Rodger has estimated the outturn from Upper Burma at 25,000 cu. ft. (34). In Uttar Pradesh the tree is not found in commercial quantities.

General characteristics of the wood.—"A light to moderately heavy straight grained, medium coarse and quite even-textured, bright yellowish-brown or golden-brown wood which darkens appreciably and becomes duller with age" (34); "Wood yellow, with yellowish-brown heartwood, hard, close-grained, with a beautiful lustre, darkening on exposure to reddish-brown" (1). The freshly cut heartwood which is yellowish-brown or golden-brown is said to darken within a few hours to brown or reddish-brown. The wood works smooth under tools, has no characteristic odour or taste, is light to moderately heavy (sp. gr. approx. 0·59) with a pretty silver grain (35). It is durable under cover and fairly so when exposed to weather (3).

Mechanical properties.—Weight at 12 per cent moisture content 38 lb. per cu. ft. (34). On an average weight = 45 lb. per cu. ft.; (1) (35); 43 lb., Rodger (3). Gamble has given the following weights for samples of timber drawn from different localities :—

Great Rangit valley, Darjeeling,	3,000 feet ..	42 lb. per cu. ft.
Do. do.	1,000 ,, ..	44 ,, ,, ,,
Bamunkopri, Darjeeling *tarai*	.. ..	48 ,, ,, ,,
East Duars, Assam ..	.. ..	47 ,, ,, ,,
Nowgong, Assam ..	.. ..	42 ,, ,, ,,
Kamrup, Assam ..	.. ..	49 ,, ,, ,,

The wood is moderately hard to hard, strong and elastic. Probably a stronger timber than *Morus alba* (34).

Seasoning capacity.—It seasons well and darkens with age; any cracks which develop are rarely deep. Planks seasoned at the Forest Research Institute, Dehra Dun, came out of the process in a faultless condition, retaining also their colour.

Working qualities.—There is no record of antiseptic treatment of this wood. The wood being straight grained presents no difficulties in sawing, takes fair polish and, if suitably cut, presents a pleasing silvery grain.

Uses, Present and Prospective.—*Morus lævigata* has been described as an excellent timber, good for outdoors and able to stand weather. The wood is used in the Darjeeling hills for house building (1). In Assam, it is considered to be one of the best timbers and very suitable for furniture and cabinet making. It is in great demand for making oars of country boats (11), and also for stocks, spokes, poles and shafts of carriages and carts and for furniture. It is also used by the Assam–Bengal railway for carriage and waggon construction (34). In Burma it is used for gun-stocks, planking, furniture, cart-shafts, yokes, carving and turnery. It is a valuable timber which "deserves to be better known and to be more employed for furniture, cabinet work, and perhaps tea-boxes, J. S. Gamble. Tests carried out at the Forest Research Institute, Dehra Dun, indicate that the timber is suitable for the manufacture of low-grade plywood.

Minor Forest Produce.—The long, cylindrical, yellowish-white or pale-purple fruit, which ripens from March to May, is eaten, though incipidly sweet and of little value (36).

Trade.—A valuable timber, which could readily be marketed in Calcutta and elsewhere, were the supply to exceed the local needs. A tree to be encouraged and worth cultivating (Pearson and Brown).

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MEDICINAL PLANTS OF KANGRA VALLEY

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The valley of Kangra and adjacent hills form the northernmost part of the Punjab (India). The outskirts touch the boundaries of Tibet and Kashmir State in the North and Himachal Pradesh in the West and the East. The region comprises an area of about 96,000 square miles out of which only a small portion is plain and the rest is a vast mountainous tract.

Three main ranges of Himalayas run through Kangra district and divide it into three small valleys.

1. The outer Himalayan range forms the valley of Kangra with an area of about 2,500 square miles. Beginning from the plains it extends up to Dhola Dar 17,000 feet above sea-level. The average annual rainfall is 70 inches in the valley, but Dhola Dar gets over 100 inches, whereas Bara Bangahal area gets very scanty rainfall. The wide range of altitude and other climatic factors exercises a powerful influence on the vegetation, resulting in a large variety of medicinal and economic plants.

At lower altitude of Hamipur, Nurpur and Kangra, amongst others the plants met with are :—*Acacia catechu, Cassia fistula, Holarrhena antidysenterica, Mallotus philippinensis, Terminalia arjuna, Terminalia belerica, Phyllanthus embelica* and *Pistacia integerrima*. *Katha*, an extract of the heartwood of *Acacia catechu* is commonly used as an ingredient in pan (betel leaf) and also in Ayurvedic medicine ; the bark of *Holarrhena antidysentrica* (*Keor*) has an established reputation in the treatment of amoebic dysentry ; the pulp of *Cassia fistula* (*Ambal tash*) is well known laxative used locally and also exported to foreign countries. The fruit of *Terminalia arjuna* and *Terminalia belerica* are used in Indian medicine in cardiac conditions and also for tannin.

Nagrota and Lambagran abound in *Adhatoda vasica, Vitex negundo, Ricinus communis* and *Sapindus mukorossi*. All these plants have medicinal properties but they are not fully exploited. Oil of *Ricinus communis* is used as a purgative and lubricant. The pericarp of the fruit of *Sapindus mukorossi* is an important source of Saponin and is exported to foreign countries.

Upper Dharmsala and Palampur areas are rich in *Berberis, Viola* and *Valeriana* species. The root and rhizome of Berberis sps., used as bitter tonic and antiperiodic ; *Viola* flowers, used as laxative and sedative in Ayurvedic medicine, *Valeriana* an important B.P. plant, used as a sedative and carminative.

2. The middle Himalayan range consists of Kulu and Saraj valley with an area of about 2,000 square miles. The general appearance of the country is very different from that of Kangra. There are no low hills, but high mountains rise up suddenly and shut in the view. The average annual rainfall is between 40–50 inches. In the upper part of the valley, the rainfall is high while in the lower part it is much less. The common trees met with are :—*Walnut, Apricot, Blue pine, Deodar, Maple* and *Horse chest-nut ;* at higher altitudes are found stunted *Oak, Birch* and *Rhododendron*.

The medicinal plants met with at Jarri, Kasol and Pulga (5,000–7,000 feet) above sea-level are :—*Atropa accuminata, Datura stramonium, Hyoscyamus niger, Phytolacca acinosa, Angelica glauca, Viola* sps., and *Valeriana wallichii*. The three Solanaceous plants *Atropa, Hyoscyamus* and *Datura* are important sources of alkaloids used in medicine.

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A plateau known as "Swanjni maidan" abounds in *Podophyllum hexandrum, Swertia angustifolia, Aconitum heterophyllum, Picrorhiza kurrova*, etc. *Podophyllum* and *Aconitum* are important plants of pharmacopoeia, the resin of *Podophyllum* is largely used as cholagogue cathartic and the roots of *Aconite* as cardiac depressant. *Picrorhiza kurrova* a substitude of *Gentian kurroo* of B.P. and *Swertia angustifolia* are used in Ayurvedic and Unani medicine as bitter tonic.

At higher elevation around Swanjni, Nagar and other places (12,000 feet) above sea-level, the plants met with are *Jurinea macrocephala, Rheum* sps., *Aconitum chasmanthum. Jurinea macrocephala* (Dhoop) is used in India as incense in religious places and also in Unani medicines.

3. In the inner Himalayan range comes Lahoul and Spiti with an area of about 5,000 square miles, which is outside the monsoon zone. The average elevation of both the cultivated and inhabited part is more than 10,000 feet above the sea-level. The average annual rainfall is very low and never exceeds 15 inches per year. The dominant plants are :— *Artemisia brevifolia, Juniperus recurva, Juniperus macropoda, Juniperus communis, Carum bulbocastanum, Ephedra gerardiana, Rheum* sps., and *Saussurea lappa*. *Artemisia* is an important source of the drug santonin but it has not been exploited so far. The berries of *Junipers* are used as stimulant and for flavouring gin. *Ephedra gerardiana* is the source of ephedrine which is an important medicine for bronchial asthma, hay fever and circulatory collapse. These two drugs are not being extracted in large quantity due to high charges of transport. *Rheum* an important pharmacopoeial plant is largely used as purgative and stomachic bitter. *Saussurea lappa* was largely cultivated in this part of the country and was exported to China, where it was used as incense and in certain medicines. But the trade of this drug declined during recent years, and consequently the cultivation has been stopped for the present, due to low prevailing prices. It can be good source of income if the oil is extracted from this drug.

The climate of Kangra region as a whole is very pleasant throughout the year except for two months of summer, when it gets quite warm at the lower altitudes. The mean temperature is 80°F. except at high altitude where it falls below zero, during winter.

The principal rocks of Kangra district are gneiss, shales, schists and quartzites with occasional bands of intrusive granite. The character of the underlying rock exercises a powerful influence on the composition of the forest vegetation and medicinal herbs. In the forest, the ground is often covered with a thick layer of old pine needles in various stages of decomposition. These combined with the porous soil produce an ideal soil for the growth of the medicinal herbs and these thrive best in the protected areas.

From time immemorial, this part of the country was well known for its abundance of medicinal herbs and large quantities have been exported from time to time but there has never been scientific and organized approach to this problem. This can be well imagined by going through the statistical data collected from the various drug markets of the valley. In the past, even with the comparatively low prices prevailing at the time, this district had an annual income of 80 to 90 lac of rupees from the sale of medicinal herbs. At the present time, inspite of the considerably higher prices obtained, the income derived from this source is much less than before. In 1950 the income was only 25 to 30 lac. Thus it is evident that unless proper steps are not taken immediately, this source of income will practically disappear within a short time, to the detriment of the inhabitants of these areas.

The main reasons for this decline are that the quality of drugs has deteriorated. This is due to two reasons. The collection of drugs is in the hands of ignorant people who do not make collections at the proper time of the maturity of plant and, therefore, quality has deteriorated. Secondly there has been much adulteration of collected drugs before sending them to the market. Unless both these factors are properly controlled the situation is bound to deteriorate further.

TABLE I.—*A list of drugs extracted from Kangra valley*

Serial No.	Botanical Name	Local Name	Part used	Season of collection	Quantity collected per year in Maunds	Price per Maund	Locality
						Rs. As.	
1	*Acacia catechu* ..	*Katha*	Extraction of wood	Autumn	5,000	250 0	Hamirpur, Kangra and Nurpur.
2	*Atropa acuminata* ..	*Belladonna*	Roots and leaves	July	100	250 0	Kangra, Sali and Parbati.
3	*Aconitum heterophyllum* ..	*Atis, Patis*	Roots	Autumn	150	800 0	Lahoul, Ohal and Bias valley.
4	*Adiantum caudatum*	*Parshoshan*	Leafy part	June to Aug.	200	32 0	Bias valley, Mandi and Kangra.
5	*Acorus calamus* ..	*Barch*	Rhizome	Autumn	200	20 0	Kangra and Bias valley.
6	*Allium rubellum* ..	*Jangli Piaz*	Bulb	Autumn	50	8 0	Parbati and Bias valley.
7	*Ajuga bracteosa* ..	*Neel Kanthi*	Whole plant	July	75	45 0	Kangra and Kulu valley.
8	*Angelica glauca* ..	*Chalora*	Roots	Autumn	100	25 0	Kangra, Sali and Parbati valley.
9	*Artemisia brevifolia*	*Seski*	Buds and leaves	Aug. to Oct.	100	90 0	Lahoul and Spiti.
10	*Berberis aristata* ..	*Rasaunt*	Roots	Autumn	500	55 0	Dharmsala and Kulu valley.
11	*Betula utilis* ..	*Bhoj Patar*	Bark	Autumn	100	20 0	Kangra, Dharmsala and Bias valley.
12	*Butea frondosa* ..	*Dhak*	Gum	Dry weather	17	80 0	Kangra and Dehra Tehsil.
13	*Cassia fistula* ..	*Amaltash*	Pods	Autumn	10,000	4 8	Nagrota, Ranital, Mangwal, Guler and Kangra.
14	*Cinnamomum tamala*	*Tej Pata*	Leaves	July	200	25 0	Nagban, Mandi, Harabagh and Kangra.
15	*Carum bulbocastanum* ..	*Kala Zira*	Seeds	November	100	160 0	Lahoul.
16	*Datura fastuosa* ..	*Kala Datura*	Leaves and seeds	July, Nov.	25	15 0 80 0	Bias valley.
17	*Datura stramonium*	*Sufed Datura*	Leaves and seeds	July, Nov.	25	12 0 50 0	Bias and Kangra valley.
18	*Euphorbia hypericifolia* ..	*Hazardana*	Whole plant	July to Aug.	12	70 0	Bias valley.
19	*Ephedra gerardiana*	*Asmani Buti*	Whole plant	August	150	40 0	Lahoul and Spiti.
20	*Hydrocotyle asiatica*	*Brahmi*	Whole plant	June to Aug.	100	75 0	Kangra and Jaijnath.
21	*Hedychium spicatum*	*Kapoor Katchri*	Root and Rhizome	Autumn	400	30 0	Kangra valley and Sali.

NOTE :—Prices are subject to fluctuation.

(contd.)

TABLE I.—*A list of drugs extracted from Kangra valley*—(concld.)

Serial No.	Botanical Name	Local Name	Part used	Season of collection	Quantity collected per year in Maunds	Price per Maund	Locality
						Rs. As.	
22	*Hyoscyamus niger* ..	*Bujr Bhang*	Leaves	June to Aug.	100	100 0	Kulu valley.
23	*Jurinea macrocephala* ..	*Gugal Dhup*	Roots	Autumn	1,500	60 0	Kangra, Parbati, Hurla and Saraj.
24	*Podophyllum hexandrum* ..	*Ban-kakri*	Roots	Autumn	800	140 0	Kulu, Mandi and Uhal.
25	•*Picrorhiza kurrooa* ..	*Karroo*	Roots	Autumn	1,000	80 0	Kulu, Bhuntar, Palampur.
26	*Polygonatum verticillatum* ..	*Salib Mishri*	Roots, Rhizome	Autumn	25	240 0	Kulu, Parbati, Palampur.
27	*Polygonum amplexicaule* ..	*Anjbar*	Rhizome	Autumn	1,000	45 0	Kangra valley.
28	*Phyllanthus emblica*	*Amla*	Fruit	Autumn	2,000	10 0	Kangra valley.
29	*Pueraria tuberosa* ..	*Bish-khapra*	Roots, Rhizome	Autumn	8	not known	Kangra and Bias.
30	*Phytolacca acinosa* ..	*Jharka*	Leaves, roots	July, Autumn	280	15 0	Parbati, Hurla and Saraj.
31	*Plantago ovata* ..	*Isabghol*	Seeds	Autumn	20	60 0	Kangra valley.
32	*Quercus incana* ..	*Sita Supari*	Acorns	Autumn	200	10 0	Dharmsala and Kulu.
33	*Rhododendron campanulatum* ..	*Kashmiri Pata*	Leaves	July	500	25 0	Kangra, Bias and Uhal.
34	*Rheum emodi* ..	*Chuchi*	Roots, Rhizome	Autumn	300	10 0	Kulu and Kangra valley.
35	*Swertia angustifolia*	*Chirata*	Whole plant	July	600	60 0	Kulu and Kangra valley.
36	*Saussurea lappa* ..	*Kuth*	Roots	Autumn	4,500	60 0	Lahoul and Kulu valley.
37	*Sapindus mukorossi*	*Ritha*	Epicarp (fruit)	Autumn	40,000	13 0	Kangra valley.
38	*Skimmia laureola* ..	*Nera*	Leaves	July to Aug.	5	not known	Kulu valley.
39	*Taraxacum officinale*	*Dhudhli*	Root	Autumn	300	45 0	Kangra, Kulu and Parbati.
40	*Taxus baccata* ..	*Brahm Dandi*	Bark and leaves	Autumn, July	250	17 0	Mandi, Kangra and Kulu valley.
41	*Terminalia chebula*	*Harrar*	Fruit	Autumn	2,000	13 0	Kangra valley.
42	*Terminalia belerica*	*Beherra*	Fruit	Autumn	700	5 0	Kangra and Palampur.
43	*Thymus serpyllum*	*Ban Ajwain*	Whole plant	July to Aug.	100	12 0	Bias and Kangra valley.
44	*Thalictrum* sps. ..	*Mamiri*	Root	Autumn	30	30 0	Bias and Kangra valley.
45	*Viola* sps. ..	*Banafsha*	Flower	April to July	150	400 0	Mandi, Palampur, Kulu and Rala.
46	*Valeriana wallichii*	*Mushak-bala*	Root and Rhizome	Autumn	800	40 0	Mandi, Palampur and Kulu valley.

NOTE :—Prices are subject to fluctuation.

TABLE II.—*A list of medicinal plants which are found in abundance but not extracted to its proper extent, due to meagre margin of profit and lack of market*

Serial No.	Botanical Name	Local Name	Availability	Locality
1	*Acorus calamus*	*Barch*	Abundant	Kangra and Kulu valley.
2	*Adiantum caudatum* ..	*Parshoshan*	Abundant	Kangra, Kulu and Saraj.
3	*Adhatoda vasica*	*Basooti*	Abundant	Kangra, Jogindarnagar and Uhal.
4	*Angelica glauca*	*Chlora*	Very common	Parbati, Saraj and Lamadag.
5	*Artemisia brevifolia* ..	*Seski*	Abundant	Lahoul and Spiti.
6	*Atropa acuminata*	*Belladonna*	Common	Kulu and Parbati.
7	*Berberis aristata* and other sps.. .	*Rasaunt*	Abundant	Kangra, Kulu and Saraj.
8	*Bombax malabaricum* ..	*Simbal*	Very common	Kangra.
9	*Bryophyllum calycinum* ..	*Zakhemi-Hiyat*	Common	Kangra and Kulu valley.
10	*Chenopodium* sp.	..	Common	Kangra and Kulu valley.
11	*Carissa spinarum*	*Garna*	Abundant	Kangra valley.
12	*Cassia fistula*	*Ambal Tash*	Abundant	Kangra valley.
13	*Datura alba*	*Datura*	Common	Kangra and Kulu valley.
14	*Datura tatula*	*Datura*	Common	Kangra and Kulu valley.
15	*Datura stramonium* ..	*Datura*	Common	Kangra and Kulu valley.
16	*Dryopteris* sps.	*Lingri-ki-jar*	Abundant	Kangra, Kulu and Parbati.
17	*Ephedra vulgaris*	*Asmani Buti*	Abundant	Lahoul and Spiti.
18	*Euphorbia pilulifera* ..	..	Common	Kangra valley.
19	*Hyoscyamus niger*	*Bujar Bhang*	Common	Kulu and Parbati valley.
20	*Holarrhena antidysenterica* ..	*Keor*	Very common	Kangra valley.
21	*Hydrocotyle asiatica* ..	*Brahmi*	Common	Kangra and Kulu valley.
22	*Juniperus recurva*	*Vither*	Abundant	Kulu, Lahoul and Spiti.
23	*Juniperus macropoda* ..	..	Abundant	Kulu, Lahoul and Spiti.
24	*Juniperus communis* ..	..	Abundant	Kulu, Lahoul and Spiti.
25	*Mallotus philippinensis* ..	*Kamila*	Very common	Kangra valley.
26	*Murraya kœnigii*	*Ghandhla*	Very common	Kangra valley.
27	*Phyllanthus embelica* ..	*Amla*	Very common	Kangra and Nagban.
28	*Pistacia integerrima* ..	*Kakar Singhi*	Common	Kangra and Nagban.
29	*Plantago ovata*	*Isabghol*	Very common	Kangra valley.
30	*Pueraria tuberosa*	*Baidan Kund*	Common	Kangra and Kulu.

(contd.)

TABLE II.—*A list of medicinal plants which are found in abundance but not extracted to its proper extent, due to meagre margin of profit and lack of market*—(concld.)

Serial No.	Botanical Name	Local Name	Availability	Locality
31	*Punica granatum*	*Anardana*	Very common	Kangra and Kulu valley.
32	*Ricinus communis* ..	*Arindi*	Abundant	Kangra valley.
33	*Rhododendron campanulatum* ..	*Kashmiri Pata*	Abundant	Kangra, Kulu and Saraj.
34	*Swertia angustifolia* ..	*Chireta*	Very common	Parbati, Kulu and Saraj.
35	*Sapindus mukorossi* ..	*Ritha*	Abundant	Kangra and Nurpur.
36	*Sexifraga ciliata*	*Pakhan Bel*	Abundant	Kangra, Kulu and Saraj.
37	*Skimmia laureola*	*Nera*	Abundant	Kangra, Kulu and Saraj.
38	*Terminalia arjuna* ..	*Arjun*	Very common	Nurpur and Kangra.
39	*Terminalia belerica* ..	*Bahera*	Very common	Nurpur and Kangra.
40	*Terminalia chebula* ..	*Harrar*	Very common	Nurpur and Kangra.
41	*Thymus serpyllum* ..	*Ban Ajwain*	Abundant	Kulu, Kangra and Saraj.
42	*Taraxacum officinale* ..	*Dhudhli*	Abundant	Kulu, Kangra and Saraj.
43	*Viola* sps.	*Banafsha*	Abundant	Kulu Kangra, and Saraj.
44	*Valeriana wallichii* ..	*Mushakbala*	Abundant	Mandi, Parbati and Saraj.
45	*Vitex negundo*	*Bana*	Very common	Kangra and Nurpur.
46	*Zanthoxylum alatum* ..	*Tirmera*	Abundant	Kangra and Kulu valley.

TABLE III.—*A list of B.P. drugs with their chemical analysis*

Botanical Name	Vernacular Name	Active principles	Official standards
Berberis aristata (roots) ..	*Rasaunt*	Alkaloids, 1·72–2·97	Not less then 1 per cent alkaloids.
Datura stramonium (leaves) ..	*Sufed Datura*	Alkaloids, 0·22	Not less than 0·25 per cent alkaloids.
Holarrhena antidysenterica (bark) ..	*Kurchi*	Alkaloids, 1·1	Not less than 2 per cent alkaloids.
Podophyllum hexandrum (rhizomes)	*Ban-kakri*	Resins, 11·2–18·7	Not less than 8 per cent resins.
Artemisia brevifolia (leaves and flowering tops)	*Seski*	Santonine traces	Not less than 0·75 per cent santonine.
Ephedra vulgaris (whole plant) ..	*Asmani Buti*	Alkaloids, 0·49	Not less than 1·25 per cent alkaloids.
Chrysanthemum cinerariefolium (flowers)	*Pyrethrum*	Pyrethrins, 0·35	Not less than 0·4 per cent pyrethrins I and II.
Atropa accuminata (leaves) ..	*Belladonna*	Alkaloids, 0·48	Not less than 0·3 per cent alkaloids.
Rheum emodi (roots)	*Rim Cheni*	Alcohol extr. 44·2 Acid insol. ash, 0·71	Alcohol soluble extr. not less than 30 per cent ; acid insoluble ash more than 1 per cent.
Carum bulbocastanum (seeds) ..	*Zira*	Essential oil, 8·6	
Juniper recurva (berries) ..	*Vither*	Essential oil, 1·56	
Juniper communis (berries ..	..	Essential oil, 1·3	
Sassurea lappa (roots) ..	*Kuth*	Essential oil, 0·52–1·3	

From a perusal of the tables it would appear that the valley is rich in herbal resources and can be exploited with advantage both to the pharmaceutical industry and the people of the locality, if only proper methods are adopted for their exploitation. Ruthless extraction of drug plants particularly of the root drugs would lead to their total extinction. There should be extraction by rotation to allow the plants sufficient time for natural regeneration. Artificial cultivation may be adopted where natural regeneration has failed. For this purpose a model drug farm would be a great asset to educate and initiate the local inhabitants to take up drug farming in their spare lands.

The marketing of crude drugs requires careful handling and should be controlled by a Government Agency in some way, so as to eliminate the factors responsible for adulteration, bad storage or poor grading. There is no reason, why, if the extraction and marketing is done on the scientific lines, this region should not contribute abundantly to the steady supply of standardized, potent and genuine crude drugs to the Pharmaceutical Industry.

My thanks are due to Col. Sir R. N. Chopra for going through the manuscript and for chemical analysis of the drugs done under his guidance at the Drug Research Laboratory, Jammu.

WILD-LIFE IN ASSAM

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India is the richest country in the world in respect of her fauna and flora. Starting from the lion (*Panthera leopersica*) the king of animals, there is hardly any type of animal family that is not represented in this great continent. Assam is the richest of all the states in India in this respect. She also possesses some rare type of animals, e.g., the Rhino which is getting extinct in other parts of the world. Due to clearing of jungles, and indiscriminate shooting, wild-life in this country is getting rarer day by day and unless we cry a halt in this respect, we shall not only lose our rich fauna and flora, but also lose all our fertile soil that is getting washed away. Our province, Assam, had been particularly fortunate in bounty of nature and it is our precious heritage that we must protect by all possible means.

2. Of all the animals that inhabit Assam, that majestic mammoth, the elephant (*Elephus maximus*) takes the pride of place. From the Sadiya Frontier Tract down to Goalpara, this animal is found in all our forests and at times turns out a nuisance by destroying crops grown near the forests. Nevertheless, this animal should have all our sympathy and ruthless destruction advocated by certain people must be resisted, if we want to preserve this grand animal and profit by its existance. Forest Department has a regular cycle of catching surplus animals by *Khedda* and *Mela Shikar*, but this is often upset by other considerations and we must stop them for the good of the animal. It is estimated that we have about 5,000 elephants and quota of catch every year is over 300. Government derive a handsome yearly revenue of about Rs. 5 lacs by sale of elephants.

3. I give second place to rhinoceros (*Rhinoceros unicornis*), the remnant of the interesting beasts that flourished in ancient times. Three varieties *R. unicornis*, *R. sondaicus*, *R. sumatrensis* (two-horned rhino) were found before, but only *R. unicornis* is found in Assam. It is a massive animal, short-sighted and when enraged, is most ferocious. They have been badly slaughtered in the past, due to the medicinal value attributed to their horn and flesh. But Forest Department is now taking all manner of precautions for its protection in reserves and sanctuaries. I could see as many as 18 rhinos in course of a day with the Hon'ble Forest Minister, in Kaziranga game sanctuary sometime ago. It is easy to kill this animal, as it follows a particular track for depositing its excreta till a big heap is formed and all that is needed is to lie in wait and use powerful bullet. It likes chiefly grass land with mud pools. They are still found in different forest sanctuaries.

4. Buffalo (*Bubalus bubalis*) which was very common in forests of Assam, are now confined to a few reserved forests and sanctuaries. Some very large horned specimens are found in Manas and Pobha game sanctuaries. Wild buffaloes breed freely in Assam with domestic herds and improve the local breed which is one of the best in India. Buffaloes like grassland with mud holes like rhinos.

5. Bison (*Bibos gaurus*) called Mithun or gaur is found in the deciduous forests of Assam. It is a powerful beast, but does not attack human beings at sight which some wild buffaloes often do. Its habits are like those of buffaloes. Having reared a bison calf left forlorn by its mother, with the milk of foster buffalo mother, I found their habits similar to buffaloes and I think we could interbreed bison with buffalo.

6. Abors in the Sadiya Frontier Tract keep bison in semi-wild state and it is not unusual to find them grazing in the forests near their villages. Another kind of Mithun (*Bibos*

banteng barmanica) is found in the Mishmi and Lushai Hills. They are actually bantings, not gaurs and are reared like Mithuns by the Mishmis and Lushais.

7. Of all the carnivora of Assam, the tiger (*Panthera tigris*) is the foremost denizen of the forest and is found in all parts of Assam, but more frequently in the deciduous forests. As a rule, Assam tiger is not a man-eater, but occasionally taste of human blood have turned some as man-eaters. On one occasion, a Garo Hills tiger killed about 90 persons, but curiously enough, it was only the Garos that were the victims and not outsiders whose dissimilar dress was perhaps the saving factor. One hears now of the man-eating Panari tiger family of Darrang District. No serious attempt seems to have been made to exterminate the pests. Forest officers have often met tiger in course of their duties and on occasion I had the experience of a tiger galloping ahead of my car one morning in Goalpara District, on a forest road. People with money and resources often organized big *shikar* in the past and killed 50 or more tigers in one camp. This no doubt gave the person satisfaction of showing off as a big *shikaree*, but it did no good either to the animal life of the province nor to the balance of nature. Such slaughter must be prevented by all means.

8. My wife and I had the rare fortune of rearing up two tiger cubs which were found starving in a rice-field in Goalpara forests and of studying their habits. Their mother was unfortunately killed by a Governor's A.D.C., in a *shikar* camp. They were so domesticated that when they heared the footsteps of my wife coming down the steps of our Dhubri bungalow, they made a peculiar sound begging for food and for patting on the back. It is a pity that I have not got the photos of the animals in their frolic with us for exhibition. They were presented to the Zoo in Calcutta when they were the size of dogs and began to be mischievous. Once they pulled a goat down to the ground by the ear and we thought it then wise to get rid of them.

9. Next to tiger, leopard or panther (*Panthera pardus*) is the most common carnivora that takes toll of domestic animals. They live chiefly near human habitations and fowls, goats, dogs and cattle are its usual prey. It cannot tackle big beasts like buffaloes, but unlike tiger it can climb up trees.

10. Civet cats (*Paradoxurus hermaphroditus*) are found in Assam, but in Garo Hills district they are found in plenty. They are very destructive to poultry and small domestic animals and usually live in jungle close to villages.

11. Wild dog (*Cuon alpinus*), that scourge of wild-life, is found in most places of Assam and destroy much game. Sitting out in front of a forest bungalow and reading a book in mid-day, suddenly I discovered a barking deer running towards the bungalow. Presently a wild dog which, I thought never existed in Sylhet in those parts, appeared from the jungle chasing the deer which found human beings less dangerous than the wild dog. This animal should be shot at sight.

12. Hyænas (*Hyæna hyana*) are rather rare in Assam, but they, like jackals, play very useful part of scavengers and are not to be despised. Only once I have seen a hyæna eating a carcase in the daytime, while going on the Barak River by a boat.

13. Martens (*Charrania flavigula*) are found in the dense tree forests, but chiefly in the hills and are very destructive to birds and other small animals. Their peculiar habit of jumping off from tree to tree in search of birds and eggs make these at once noticeable. They are fairly common in the Garo Hills and in the Sadiya Frontier Tract.

14. The sloth bear (*Melursus ursinus*) is a common denizen of short grass jungles in the midst of forest and being short-sighted and dull of hearing, it is dangerous to single individuals, if suddenly discovered by the animal, but it will run away in presence of a group

of men. A very interesting animal rapidly disappearing is the racoon, a species of cat bear (*Ailurus fulgens*) found in the Mishmi hills. Their skins have a beautiful yellow-brown colour and much sought for by Mishmis who often make their hats of these skins and also bring them to the Sadiya market for sale. This rare animal is, I am afraid rapidly disappearing.

15. Deer species was very well represented in Assam, but some are already extinct in some districts of Assam. *Barasingha* (*Rucervus duvaucelli*) was quite common in Goalpara forests about 30 years back, it is not found there anymore. I saw probably the last specimen in Maula Block of Western Range near Bengal border about 15 years back and it has not been reported since.

16. In the higher Mishmi hills, one can find musk deer (*Moschus moschiferous*) which are killed in large numbers by the Mishmis every year to provide musk for the Sadiya market where a regular trade goes on in the cold weather in particular.

17. Sambhar (*Rusa unicolour*) is found in all districts, but spotted deer (*Axis axis*) is found in deciduous forests only in three districts along the foot-hills of the Himalayas. It is not found on the eastern side of Darrang district. Hog deer (*Hyelaphus porcinus*) is found in plenty in our game sanctuaries, but are getting rare outside reserved forests. So also is the case with barking deer (*Muntiacus muntjak*). Poaching even in the reserves and non-observance of game laws have been responsible for great reduction of deer. 'It was not an uncommon event for a Divisional Forest Officer visiting some interior parts of the forests in the rainy season to discover a poacher's camp where venison was being dried up over a *machan* for removal and storage for an year's consumption. I regret to say that no stringent action was taken by the Civil Authorities to control unauthorized use of guns. Meches, Cacharis and other aboriginals were found to be the worst offenders in this respect. Forest subordinates engaged in anti-poaching work had often duels with them.

18. The most destructive animal to our young sal plantations is the pig. It has been my heart-breaking experience to see fully-stocked sal seedling lines being dug up clear and all succulent roots of young seedlings eaten up by pigs. They are very prolific breeders and have to be made an outlaw if sal plantations are to be made successful. I have been baffled by them even after digging trenches and permitting villages to shoot them and trap them by nets. A pigmy hog has been found by Mr. Mackrell, a keen sportsman, in Goalpara district, but this animal is nearly extinct.

19. Porcupine, that interesting animal with quills on its body as a protective measure is found in some forests. They are destructive to young simul with succulent growth. Our forests abound in many other smaller animals of which mention must be made of pangolia. (*Manis crassicaudata*), the scaly ant-eater. They are rare and deserve our sympathy and protection.

20. Of the reptiles, the great monitor lizard whose skin is prized for making ladies bags, shoes, etc., is found in plenty and eaten by the aboriginal people who kill them at sight. Python, the largest reptiles commonly called 'Ajgar' is found in most of our forests. It is not poisonous, but crushes the animals it catches by coiling round and then swallows them. It is known to swallow animals as big as barking deer and one occasion, a dead python was seen by me in Goalpara with horns of the barking deer protruding from its body. Apparently it swallowed the deer but could not manage the horns. Large poisonous snakes are not very common, but occasionally hamadryads are found in drier forests. Once I had found one 10 feet long run over by our forest Railway in Goalpara.

21. Of the monkeys, several species are found in Assam, e.g., *Macaca mulatta* (common monkey) *Macaca assemensis* (no orange red hue in the hump and found in high elevation),

Semnopithecus entellus (Langur) *Trachypithacus pileatus* (capped Langur) and hullock (*Hylobates hoolock*) but the last one is the most interesting of the lot, being tailless and having a high pitched howl which is taken up by all the members of the family and resounded. It is not found on the north bank of the Brahmaputhra.

22. Our province abounds in birds of all kinds, viz., peacocks, black pheasants, fowls, patridges, quails, ducks and other migratory birds. Special mention must be made of florican which was very common in deciduous forests on open glades, but they are getting rare day by day. I used to know of places where one could be certain of finding them. Their peculiar way of taking to wings straight up from the ground and the whistling of female birds in flight are the most interesting and peculiar characteristics by which they could easily be recognized. Another interesting bird peculiar to Assam and confined to the Garo Hills and K. and J. Hills only is the peacock pheasant, having the eyes of the peacock on its feathers, but the features of the pheasant. Birds having been shot by all and sundry, having guns for protection of crop and sport, without any observance of game laws, they are getting rarer day by day. Outside reserved forests, they have already got very scarce and some birds like pink-headed duck (*Rhodonessa caryophyllacea*) which I have seen before in Goalpara District, is there no more. People are ignorant and very slack in observing the game laws and in course of my tour, I have found policemen, custodians of our laws, going out for shooting birds and animals in close season, and when accosted they pleaded ignorance !

23. Assam rivers abound in sporting fish like *Mahseer*, *Boka*, *Katli*, etc., and one can find much pleasure and recreation with rod and line in our forest camps. Indeed we used to have some very keen Europeans who used to always spend their short holidays on our rivers in fishing. Here again, poaching goes on and netting and night lining are very common in our rivers, resulting in indiscriminate destruction of young fish.

24. Nature has endowed our province with rich fauna and flora but it is a fast disappearing asset. We must make our people realize the gravity of the danger of extinction. Indeed some of these rare animals have already been extinct. There is a place for all animals in Nature and a definite function to play which due to our ignorance, we often overlook. We should treat wild-life with sympathy and consideration and not kill them *ad lib.*

25. I wish to emphasize here that Assam has not got vast forests as some people think. 11% of the total area under reserved forests is hopelessly inadequate where it should have been 25%. We have got sanctuaries covering only 400 square miles which again is inadequate. Ordinary people have no forest sense and cutting trees and killing animals are in their blood. We have to educate them. If we properly protect our fauna and flora and develop our few sanctuaries by providing amenities to visitors and tourists, then apart from the scientific and cultural value, we should be able to add substantially to our state exchequer. This needs men of vision and practical wisdom who should be able to work with disinterested zeal and enthusiasm.

SINGLE STEM SILVICULTURE

BY K. P. SAGREIYA, I.F.S.
Divisional Forest Officer, Jubbulpore, M.P.

My two articles under the above caption have evinced comments from far and near, and, therefore, I crave the indulgence of some space in your esteemed journal to answer these.

Naturally the first to take notice of it were certain Madhya Pradesh foresters. The Conservator and the Divisional Forest Officers of the Western Circle which includes the Betul Division where I developed the "technique" in the course of a study tour in the teak forests inspected some of the areas thinned by me and then recorded the following comments :

> "The conference studied Mr. Sagreiya's articles on thinnings in young teak crops on the ground, in the thinned and unthinned crops, and considers that the principles given in his article are broadly correct and provide a sound basis for working plans officers to include in their plans, and also indicates the lines of research which the Silvicultural branch must immediately engage on",

and further

> "The prescriptions for thinning must be simple and unambiguous, and capable of being carried out even by forest guards".
>
> "The Betul staff when carrying out the thinnings at the tenth year were clear-felling the understorey of bamboos. *This was considered to be a mistake*".
>
> "After carrying out sample thinnings and considering the spacing derived from the Yield Tables, Mr. Hewetson's formula $S' = 1 \cdot 5 \ (D'' + 5)$ and Mr. Sagreiya's formula $S' = 2 \ (D'' + 3)$, the conference agreed that the Yield Table spacing was not wide enough for the crops of coppice origin. It was a matter of debate whether Mr. Sagreiya's spacing was not too wide, but provided there is no danger of the area being invaded by grass it gave a good general guide. This point can only be decided by careful research. *Provided the undergrowth is not cut, a wider spacing is possible.* The conference, however, found the spacing given by Mr. Hewetson's formula was safer".
>
> "In regard to the interval between successive operations it was agreed that the first operation, which should be called 'cleaning' should be carried out at the fifth year, the second operation called the 'first thinning' should be at the tenth year and the second thinning probably at the twentieth year".
>
> "In regard to Single Stem Silviculture, advocated by Mr. Sagreiya, it was considered that in well-developed crops there was little difference between this method and the usual method of thinning. *The conference observed that it was essential to lay down a spacing to be observed as, if crops are thinned by eye, there was a very great variation between the marking of individual officers*".
>
> "In the 'first thinning' spacing should provide the main basis for selection of trees to grow on, tempered by the retention of the best stems. The objective of the marking Officer should be to leave the best stems (elites) spaced as nearly as possible at the prescribed distance and to avoid gaps in the crops".
>
> (Italics and parentheses mine).

Acknowledging these encouraging comments, *inter alia* I pointed out that the main purpose of the article in question was to provide a simple measure for comparing the performances under different regimes in vogue in the province, and more so, to simplify the operation

of thinning irregular crops so that the work could be carried out through the agency of even untrained forest guards without any danger of over-thinnings. Mr. Hewetson's formula is as good as mine, as a first approximation. Incidentally mine represents a spacing diameter trend which is more or less parallel to that of the Yield Tables, and gives what has been regarded as the heaviest permissible thinning.

Besides the proceedings of the conference, Messrs. Hewetson and Kulkarni raised certain other objections which I answer here. (The objections are apparent from the answers and are, therefore, not quoted).

(*a*) It is desirable to get single Stem-minded from the very beginning especially as S.S.S. is primarily recommended

(i) for crops that are understocked in respect of teak (which are the most frequent)

and (ii) for fully stocked crops in which there is great variation in vigour, size and age of stems (which again are quite frequent).

Fully stocked crops of uniform, vigour, size and age outside our plantations, are few and far between.

(*b*) The regime proposed by me is at best a shrewd guess based on observations regarding average growth conditions and the fact that eventually seedlings beat coppice shoots.

(*c*) The cutting back of all interfering bamboos and those that are likely to interfere before the next thinning is due, is very desirable. Such cutting back is not likely to exterminate the bamboos as is the case when they are repeatedly cut back. If this treatment is considered too drastic from the soil-protection point of view, I suggest as an alternative, that just as elites of teak are reserved, good bamboo clumps may also be selected and reserved, say 40 per acre, uniformly spaced and properly tended. Teak stems that are suppressed by these bamboos should be allowed to languish in the same manner as bamboos under the elites of teak are kept back. Eventually this should give an ideal teak stand with an understorey of bamboos.

After this, my second article of the series (and there are two more) appeared in 1947 July *Indian Forester*. On this Mr. Datta, Silviculturist, Madhya Pradesh and Berar sent me a long note of comments. I deal with this below (omitting comments which were obviously based on a misreading of my note). Mr. Datta observes :

> "You have recommended first thinning in site quality III at 10 years. In the illustration this has been carried out in 9 years. You have reduced 1,000 stems to 220 stems per acre at the very first thinning at 9 years. According to your own recommendations the number should have been 250 after second thinning at age 20 years in site quality III. Either the recommendation in Table I is incorrect or the thinning has not been carried out in the plot according to the recommendations made. Two thinnings have been carried out in one operation at the age when only the first thinning should have been done".

This seemingly adverse comment, in fact, fully concedes the claims I have made for my S.S.S. The particular thinning illustrated is what was silviculturally justified in the crop without any regard to its past history, age or quality. The plot in question was planted 9 years ago on an area shown in the Working Plan as Q III and it has had two haphazard thinnings already. Actually the site-quality is definitely II. The N per acre after thinning is 240 which corresponds to a 'normal' crop-diameter of 4·5 inches. The average diameter is 4·0

inches because of poor growth in the North-East corner. It will thus be seen that the crop has not been thinned out too much, especially as in the Madhya Pradesh, we generally thin at intervals of at least 10 years.

Since then, a review of my first article by Mr. Laurie has appeared in the *Empire Forestry Journal* (Vol. 26, No. 1, 1947, pp. 137–38). He observes :

> "The fact that average crop diameters and numbers of stems per acre cannot be used for determining the spacing of individual trees according to their individual diameters and that yield table diameter distributions for fully stocked uniform crops cannot under any stretch of imagination be applied to the irregular crops with uneven stocking and which are partly of coppice and partly of seedlings or seedling-coppice origin, seem to have been tacitly ignored".

My obvious answer to this is that I have *deliberately* ignored these fundamental facts to arrive at a rough-and-ready, and hence practical, method of carrying out thinnings in admittedly irregular crops for which no precise theoretical basis is possible. Using my formula as a guide, the best stems can be given more or less optimum freedom and thus over-thinning, under-thinning or haphazard thinning can be guarded against in early life. The method also helps us to arrive at, as nearly as possible, a complete canopy of almost all well-developed stems so that in later life strict silvicultural thinnings can be carried out.

Inspecting officers have considered the resulting crop almost ideally spaced out. In fact, some one called it a *natural plantation*, and thus conceded my main contention even if it be at some sacrifice of total value-yield. My method is certainly less open to objection than the present procedure of thinning by "instinct" and giving casual inspecting officers complete "freedom" (my due apologies to the purists for such loose use of a scientific term) to comment on the work of their subordinates according to their mood at the moment, which the latter are obliged to accept in submissive silence ! Under my method they can at least urge that their work answers the prescribed rough-and-ready check. In fact Laurie has conceded my point when he says

> "The utility of such thinning formulæ as that proposed by the author is not as a method of conducting thinnings but in sufficiently regular crops, and under verified suitable conditions, *as a check that markings are being carried out consistently*".

I have claimed no more.

Finally I come to the somewhat scathing comments by Mr. Partap Singh of which he has sent an advance copy to me, and another to the Madhya Pradesh Silviculturist who is circulating it in the Department. Ordinarily I would have brushed them aside by an unqualified admittance (if this were necessary) that I have not made any exaggerated claims for my method. But as I have been much impressed by his excellent paper entitled "The Conception and Classification of Thinnings" which is a refreshing outlook on the stereotyped subject of thinnings, I propose to deal with his comments in detail.

I repeat, S.S.S. is a feasible method of getting irregular young crops of teak tended through the agency of untrained subordinate staff and thus clearing accumulated arrears, even while the staff deficiency continues. When I referred to the undesirability of "thinning to obtain uniform spacing or a crop of uniform size" I was not explaining away a self-created difficulty, but was merely pointing out how, if, to simplify matters for the untrained subordinate staff, we were to instruct them to do this, the results in irregular crop will be disastrous.

The objection to the "loose and incorrect" use of the word "optimum" has amused me. Is there any special meaning attached to this word in forest terminology ? Its dictionary meaning, in the attributive sense is "best or most favourable" and the Oxford

Dictionary quotes as an example "optimum temperature". Champion uses the phrase "optimum growth". I do not see how even a purist could object to its use with "development", "growing space", etc. The alternative suggested namely "determined" does not correctly convey my sense. Perhaps "prescribed" will be better but definitely less expressive than the word "optimum".

Mr. Partap Singh next refers to certain fundamental mistakes made by me. He points out (as if I had denied them) that

(*a*) "the relationship in dimensions that exists in case of crops (or the average tree) does not hold good in case of every tree forming the crop",

(*b*) "spacing is not rectilinear single plane affair but radial and multi-plane"

and (*c*) "circles cannot occupy space completely".

Any one who knows anything about the development of crops should know that these are veritable truisms. I did not question their correctness when I proposed that as a rough-and-ready method the best developed stems might be spaced out on an observed N/D relationship on the assumption that bole d.b.h. within certain limits is proportional to the proposed freedom all round the stem. As a kid I know that space is not rectilinear.

Just as in mechanical and rod thinnings we are guided by the horizontal *distance* to the next nearest stem, i.e., freedom in one dimension, in my method, as a better approximation I have used the *area* necessary all round a stem for its best development, as the guide. I have assumed this to be a circle of a specified diameter. Mr. Partap Singh goes a step further when he takes into consideration growth of the entire crowns of trees. Some one else as a even closer approximation to "optimum freedom" might make due allowance for root-spread. Lastly, if we must be precise, we may not ignore the fourth dimension, time, and must make allowance for the season in which the thinning is actually carried out, as the rate of development of trees is not the same in all seasons. In other words, it is merely a case of how far allowance could be made for various factors which affect growth of the stems. I have deliberately sacrificed some accuracy in favour of feasibility. Any objection to this is simply meaningless.

It is then pointed out that circles cannot occupy a plane surface completely. I did not say that they did. Nor for that matter can regular hexagons of different sizes, as seems to have been assumed by Mr. Partap Singh. It is not difficult to see that the growing space in the horizontal plane available to stems in an *irregular* crop, assuming that all of them grow with equal vigour on all sides (which of course is not true), will be the polygons formed by the perpendicular bisectors of the lines joining the bases of adjacent stems. Only when the plants are of equal vigour and are situated at the vertices of *equal, equilateral triangles* will the growing spaces be equal hexagons, and will completely occupy the plane. The area covered by circles inscribed in these hexagons is about 90% of this growing space (actually $\frac{100\,\pi}{2\sqrt{3}}$ per cent).

If we must allow for the varying vigour of the plants the perpendiculars to the lines joining adjacent plants will have to be located so as to be directly proportional to their vigour. All such theoretical considerations are entirely besides my point when I am adopting a rough-and-ready method of finding out what reasonable growing space may be allowed. As a good approximation I have adopted circles of diameters proportional to the d.b.h.o.b. of the stems.

Mr. Partap Singh rubs it in, that it is a mistake to presume that my formula *truly* represents the optimum space requirement of the crop or even the requirement of every tree, etc. This is tantamount to giving the dog a bad name and then hanging him. I have never

made this claim I have merely said that such assumption gives a rough-and-ready guide for spacing out "elites" I am also not unaware of the practical difficulty in allowing a departure of plus or minus 2 feet on the formula proposed by me.

Mr. Partap Singh next criticises my proposal to check the average spacing of the elites on the basis of the "normal" N/D curve for the crop as a whole and considers it not only inaccurate but such as will bewilder the lower staff. My experience has been otherwise. After a little practice such a check becomes unnecessary. Thus, far from knocking the bottom out of the system of S.S.S. such a check as a guide in the early stages, becomes the very sheet anchor of my method. It prevents over-thinnings or under-thinnings. Strictly speaking such manipulation to conform to the "normal" N/D relationship will vitiate the freedom to individual stems but I have prescribed this in young crops primarily to avoid crops as a whole becoming a normal.

Next it is suggested that I have tried to cook a Kedgeree of free thinnings, maximum thinnings, rod thinnings, etc., and indiscriminately and loosely used certain terms like elite optimum, etc., and eventually arrived at *something not very different from ordinary very heavy thinnings* and tried to pass off as something original by giving it a self-contractory epithet of S.S.S. ? I have done nothing of the sort. I have neither plagiarized nor cribbed. If my method does result in "very heavy ordinary thinnings", my efforts have not been in vain, as I have succeeded in getting the work done through untrained staff, who are generally incapable of understanding the grade thinnings which have crown classification as their basis as opposed to the more easily comprehensible factor growing space. If I have succeeded in getting this done even in a round about way I deserve congratulation for it and not condemnation.

Personally I do not agree that my method results in a D-grade ordinary thinning as suggested. If anything it will give crops very akin to those obtained under *heavy crown thinnings*. Be that as it may, I certainly do not wish to perpetuate a Sagreya's system of tending crops if that is what is meant to be conveyed. So long as the method proposed by me can serve the purpose for which it is meant it is immaterial what name is given to it. I had to give my method a special name to express its basic concept, viz., of giving individual attention to stems rather than to crops as a whole, as this is more readily understood by the subordinate staff.

Apparently Mr. Partap Singh does not know that I am not one of those sophisticated foresters who deny the subordinate staff the credit for intelligence which is their due. On the contrary I believe that quite innocent of the highly complicated methods and the intricate mathematical checks these subordinates with their robust common sense, do carry out far better thinnings than the self-styled experts, *provided* that they are given some simple instructions for guidance. This is what my method does. Beyond this individual judgment is allowed free play.

Lastly Mr. Partap Singh cites my observation that a crop can be thinned to satisfy a particular N/D curve in more ways than one and then points out

> "If N/D is so variable would thinning 'degree' explained in the same paper (second article of the series) have any meaning ? In any case it may be added for information that this thinning degree and its graphical representation is nothing else but the measure of grades of thinning classification mentioned in the Statistical Code and adopted in compilation of multiple Yield Tables as of Deodar (Champion and Mahendru, 1937)".

As these comments are likely to convey a very wrong impression to a casual reader, I am taking the liberty of dealing with them at some length.

My observation is quite correct and anyone who has *thinned* crops, and not merely created haphazard gaps in the canopy, will know that a crop *can* be thinned, i.e., individual elites given optimum freedom for development, either to a smaller diameter (and hence larger N per acre) or vice versa. Of course it is obvious that this can be done within a small range of N/D. I am here referring to *thinnings* and *not increment fellings or orchard plantings.*

As to the reference to the Multiple Yield Tables, I was aware of the use of similar curves for the *compilation* of the Deodar Multiple Yield Tables from plots believed to have been maintained at certain intensities. What I have emphasized is the use of such curves for *maintaining* plots at specified degrees of thinning and then finding out the comparative performances of the different degrees of thinning.

There is a fundamental difference between the two. Under the method proposed by me, plots can be maintained thinned to different degrees, and then their performances judged. What is more important, the cycle can be adjusted to suit the growth conditions under each degree. In the Multiple Yield Tables this latter factor has been completely ignored. This is what I referred to by saying

> "It will be readily seen that when thinning degree controlled in the manner indicated, the various plots under comparison need not be thinned simultaneously (which is tantamount to forcing the crops to depart from their natural tendency to respond to the desired degree of thinning because successive thinnings in lightly thinned plots will be unduly delayed whereas heavier thinnings will be carried out prematurely)".

As a typical example I cite the following data from the Multiple Yield Tables in question :

Plot No. 17 Chakrata Division

Vide App. I, page 103			Vide Table 31, page 80
Top age	d.b.h.	N per acre	Thinning intensity
52	6·7	785	C/B
61	7·8	687	B
70	11·2	313	D/C
76	13·1	190	E/D
81	14·0	172	E/D

These data clearly show that in 5 successive measurements (the second and third at nearly 10-year intervals and the fourth and fifth at about 5-year intervals) the thinning intensity in one particular plot has varied from B to E-grade ! Mr. Partap Singh should have no difficulty in appreciating my contention that this is far from a satisfactory basis for compiling multiple Yield Tables of which the avowed object is to gauge the relative performances of the various intensities. It is to avoid such vitiations that I have suggested the use of predetermined N/D curves for different grades and the adoption of cycles for the various grades depending on the actual response of the trees. The normal N/D relationship, if one exists, *can* be determined.

In this connection a reference is also invited to the method proposed when using Yield Tables as a guide to thinning in the Stand and Yield Tables for Teak (Laurie and Sant Ram

Bakshi, 1940). It is suggested that when using the main crop figures as a guide to thinning (and it is admitted that these figures are based on crops which had been underthinned) on a longer cycle than 5 years, the following procedure may be adopted to get a rough correction.

> "Read at (A- 5) years the main crop *number of stems per acre* (for brief density) where A is the age of thinning, say this is n_1. Next read the density at the age (A+C−5) years where C is the thinning cycle adopted, say this is n_2. Then if the crop is normal ($n_1 - n_2$) stems should be removed leaving n_2 stems. If the crop is abnormal containing n_x stems before thinning a *proportionate degree of thinning as regards number of stems will be obtained by removing*
>
> $$\frac{n_x}{n_1} (n_1 - n_2) \text{ Stems.}$$
>
> *This maintains the same degree of abnormality in numbers of stems after thinning*".
> (Italics mine).

Mr. Partap Singh should have no difficulty in seeing how this assertion is not quite correct. One heavier or lighter than the specified degree of thinning can leave a permanent impress on the crop. It is to avoid such disturbed growth conditions that I have suggested that successive thinnings at specified degrees should be carried out on the basis of a series of N/D curves.

I do hope this somewhat longish note will convince the reader that the various objections to my method are all based on an erroneous assumption, viz., that I have claimed a theoretical basis for my formula.

All I claim is that with the assumptions made by me (which I dare say are perhaps theoretically incorrect) to derive at a rough-and-ready formula, and to arrive at a tentative cycle, the crops *can* be thinned by the subordinate staff to which no serious objections can be raised by the experts. At any rate I am not aware of any. The comments of inspecting officers on crops thinned under this method have been consistently favourable except that slight modifications have been proposed to my empiric formula. The check of average-density for crop as a whole has in fact exercised a very salutary effect which is what was intended. If and when we have the wherewithals to carry out thinnings on the so-called standard lines, my method rough as it is, must give way. Personally I doubt if we require a more precise method than this for divisional practice for the irregular mixed forests of Madhya Pradesh or even for our plantations. What we do need is to determine the theoretical N/D curve if there is one which is independent of age or quality.

I have worked out how this could be done and if the readers of the *Indian Forester* are interested I will send this for publication.

MINOR FOREST PRODUCE AVAILABLE IN WEST BENGAL

BY K. N. CHAUDHURI

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The most important items of minor produce of our forests at the moment are *khair*, honey and wax, tanning materials, canes, bamboos, *golpatta*, thatch, stones, minerals and shells. There are quite a number of other produce of known utility available in small quantities in our forests, and we have undertaken to collect detailed information on them and to ascertain their commercial possibilities. These comprise medicinal plants, spices like long pepper, vegetable dyestuffs, oilseeds, certain grasses as raw materials for paper industry, animal products like elephant tusks, rhino horns, etc. We have again certain produce available in large quantities, whose commercial utility is still unknown. We have requested the Forest Research Institute to investigate, among others, into the commercial possibilities of the following produce, available in our province in fairly large quantities :—

1. Wood of *Cryptomeria japonica* as raw material for mechanical wood pulp.
2. Grasses like *Saccharum* spp. as raw material in paper industry.

We shall now discuss the main items of our minor forest produce in detail.

I. KHAIR (*Catechu* or *Katha*)

The raw material from which this product is manufactured is the heartwood of the *khair* tree (*Acacia catechuoides*) available in fair abundance in the riverain forests of Buxa and Jalpaiguri Divisions. Prior to 1947–48, standing *khair* trees used to be sold to the *Khairwalas* of the Uttar Pradesh and they were allowed to manufacture *khair* inside the Reserved Forests by the indigenous process. The *khair* thus manufactured used to be marketed in Calcutta, along with that manufactured elsewhere, as "Janakpuri" *khair*. These "khairwallas" of Uttar Pradesh had been the sole monopolists in the trade of hand-made *khair*, and had also been the agents for the machine-made *khair* of the factory at Bareilly. With a view to producing and supplying pure *khair* to our markets under our own supervision, departmental manufacture of *khair* in the indigenous process was undertaken for the first time in 1947–48 in the Buxa Division. The experiment was continued in that division in 1948–49. In 1947–48 about 235 mds. of *khair* from 4 *bhatties* and in 1948–49 about 700 mds. from 12 *bhatties* were produced. Specimens of our *khair* were sent to the Forest Research Institute for chemical test, and their reports indicate that we have been able to improve the quality of our product considerably in the second year of our experiment. The maximum annual possibility of *khair* from our forests is estimated to be about 1,000 mds.

Although chemical tests indicate that our *khair* is of good quality it is very unfortunate that neither the *khair* traders nor the consumers are inclined to consider it as one of the best marketable varieties, particularly in comparison to the machine-made product from Bareilly. Our prices (viz., Rs. 260/- per md. for quantities less than 20 mds. each and Rs. 255/- per md. for a quantity of 20 mds. and over in one lot) are thus being considered too high. The highest offer received in 1949–50 for a bulk purchase of 100 mds. was Rs. 175/- per md. Incidentally, it may be noted that in 1948–49 we received an offer of Rs. 255/- per md. for the entire stock of 1947–48, delivery at Calcutta. This indicates, among other things, a

* The article was written by Shri K. N. Chaudhuri in 1949 and has been brought up-to-date by Shri K. L. Lahiri, Deputy Conservator of Forests in June 1951 by the addition of notes on the working of *khair* (*katha*) and the extraction and sale of honey and wax during the years 1949–50 and 1950–51.

sudden slump in the *khair* trade. The other reasons for the deadlock in the matter of disposal of our *khair* appears to be the following :—

1. *Khair* in dyeing, chemical and medicinal industries has to some extent been replaced by other synthetic substitutes.
2. Altough the demand of *khair* for use with betel leaves has not decreased, the consumers do not appear to be much concerned with the chemical purity of the product. On enquiry, it transpires that adulterated *khair* imported from Singapore as well as such stuff from other parts of in India are obtainable at about Rs. 125/- per md. The consumer appears to be quite content with this product.
3. The trade seems to honour the "finish" or external appearance of the product in preference to its chemical purity. As a result our stocks are considered to be of a poorer quality in comparison to the machine-made variety from Bareilly which has a better external colour and glaze, and whose cubes are of uniform shape and size.
4. There seems to be a ring in the *khair* trade. The *Khairuwallas* of certain regions have had the monopoly in the trade, and they tend to form a ring whenever some new manufacturer enters the market. It is, therefore, quite likely that with the publicity of our product, they have brought down the prices of their existing stocks temporarily in order to make it impossible for us to sell our product at a reasonable profit. To break this ring we tried to induce some local businessmen to enter the trade with our product. But none came forward, as either they were not sanguine of a reasonable margin of profit (being new to the line), or did not have the necessary capital.

During the quarter, April to June 1949, we had been able to sell only about 14 mds. Then we tried to push our product in the markets of outlying districts through the local Divisional Forest Officers. But there was little response from that direction. A report from the Divisional Forest Officer, Midnapore, indicated that the consumers in his area considered our prices too high. Subsequently the whole stock was disposed of by March 1950 at rates of Rs. 250/- per md. and above.

During 1949–50 about 280 mds. of *khair* were produced from six *bhatties*. As our past experience went against shifting of stock and its retention for a longer time than necessary, this stock was sold at Rs. 245/- per md. from Rajabhatkhawa in Buxa Division, where it was manufactured. During 1950–51 we have again produced about 475 mds. ; this stock has not yet been disposed of.

II. HONEY AND WAX

Formerly honey and wax, the most important minor forest product of the 24-Parganas Division, used to be disposed of on permits only. The maximum annual yield is about 6,000 mds. of honey and 1,500 mds. wax. With a view to supplying pure honey to the consuming public and industries we took the collection of honey and wax by purchase from permit-holders at the checking stations in 1949. We procured about 500 mds. of honey and 60 mds. of crude wax. They were offered for sale at fixed rates as follows :—

(*a*) Filtered honey in bottles .. Rs. 2/- per 2 lb. bottle.
Rs. 1/2/- per 1 lb. bottle.

(*b*) Unfiltered honey in tins @ Rs. 60/- per md.

(*c*) Wax @ Rs. 115/- per md.

The large consumers like Bengal Chemical and Pharmaceutical & Co. Ltd., and other pharmaceutical works and "Kaviraji" firms were expected to purchase in bulk unfiltered honey and, therefore, it was decided not to bottle up all the honey. A press note as to the availability of honey and wax with the above prices was published in the newspapers of Calcutta by the Directorate of Publicity.

Our difficulties in attracting the large consumers were due to the fact that we had allowed the major portion of the available quantity to be marketed by the permit-holders themselves. On enquiry it transpired that most of the Pharmacopoeias and traders of Calcutta had already purchased their annual requirements from the permit-holders. This indicated that we should hold the monopoly of the produce, otherwise it would be extremely difficult for us to control the supply or the prices.

Bottled honey was sold from Alipore office. It was a slow process as many of the consumers in Calcutta and the suburbs could not possibly come here for their requirements. Consequently bulk sale of bottled honey at 12½% commission was introduced and it was so arranged as to make it possible for retail sale at different centres of the city of Calcutta. Initially the response was poor as a buyer is always hesitant to purchase unknown produce. After a few months our honey gained popularity due to its moderate price and pure quality. The sale of the whole quantity of 500 mds. was completed on 20-4-50.

During 1950-51 we produced 1,100 mds. of honey and 91 mds. of wax. The wax was sold on tender @ Rs. 185/- per md. It appears that there is a shortage of genuine bee's wax for industrial purposes and the market is capable of consuming a much bigger quantity at a competitive rate.

The price of honey was raised to cover incidental expenses and overhead charges. The rates were fixed as follows :—

(*a*) Filtered honey in bottles :—

Rs. 2/8/- for a 2 lb. bottle.

Rs. 1/8/- for a 1 lb. bottle.

(NOTE :—12½% commission was allowed for bulk purchases of 200 lb. or more at a time).

(*b*) Unfiltered honey in tins :—

Rs. 80/- per md. for one lot of less than 5 mds.

Rs. 75/- per md. for each lot of 5 mds. and over.

On the experience of the previous year three departmental stalls were opened at three different centres in the city with a view to making our produce easily available for people residing in different localities of the city. Soon it was experienced that stalls could not be financially justified if opened only for honey ; much less was it economical to open the large number of shops that were necessary for bringing the produce within the easy reach of residents in a large and populous city like Calcutta. Consequently these stalls were closed down and stockists at different localities were supplied with honey at the commission rate for the purpose of retail sale. The arrangement was very satisfactory and on 1-4-51 we had a balance stock of only 84 mds. that was subsequently disposed of.

III. VEGETABLE TANNING MATERIALS

The most important vegetable tanning material of our forests is *goran* (*Ceriops roxburghiana*) bark which is known to occur in the 24-Parganas Division in fair abundance. Hitherto the *goran* bark has not been sold as a separate item ; it has been collected by firewood cutters on permits for "*goran* firewood". These permit-holders, on return to Calcutta,

strip the bark off the billets and sell them to the local tanneries. As we have neither sold the bark as a separate item nor have ever extracted it departmentally, no figures of annual possibility are available.

Goran bark, the best specimens yielding about 37% of tannin, has a bad reputation for imparting an ugly red colour to leather. Investigations carried out at the Calcutta Research Tannery have shown that by blending *goran* bark with myrabolans and the bark of *babul* (*Acacia arabica*) in suitable proportions the dull redness due to *goran* can be eliminated to a considerable extent. The most suitable mixture is one of two parts *babul* bark, one part myrabolans and one part *goran* bark. *Goran* bark has, therefore, been recommended to the trade and it deserved commercial exploitation. It would thus be worth considering if we should not undertake to collect the bark departmentally and supply the same to the tanneries ourselves.

As regards other tanning materials, myrabolans, bark of *dhundal* (*Carapa obovata*), *babul* (*Acacia arabica*) and *Sungure katus* (*Quercus pachyphylla*) are available in our forests. But none of them except possibly *Sungure katus* is available in commercial quantities. As regards the exploitation of the bark of *Sungare katus*, it is not yet a commercial proposition in view of the high cost of transport to Calcutta. When, however, a tannery is established in the Darjeeling district, it will surely find its place there.

One of the best vegetable tanstuffs of the world is the bark of the wattle *Acacia decurrens*. We have initiated experiments with this species in some of the divisions of the Northern Circle, in order to ascertain

(*a*) if the species can be grown successfully in this state, and

(*b*) even if the tree grows, whether the bark would yield that percentage of tannin which would to make it a commercial proposition.

IV. CANES

Cane is a bye-product in the regression of wet mixed forests into the extreme wet stage with the consequent disappearance of timber forest. Several species of cane of commercial utility are available in our Duars and Terai forests. The available supply of cane is wholly consumed locally for making tea baskets. In fact, the demand is greater than the available supply. The exploitation of canes has, therefore, been restricted and regulated by the Working Plans concerned, in order that a sustained yield may be maintained.

V. BAMBOOS

Several species of bamboo are available in the forests of North Bengal, both wild and planted. There is practically no local demand of bamboos from North Bengal forests except in some localities of the hill divisions as most of the villagers and tea gardens have their own bamboo plantations. As a result, the utilization of the available stocks of bamboos in the North Bengal divisions has been a problem. We have, therefore, now stopped planting bamboos in our regeneration areas. The extraction of these bamboos for paper-making is not feasible at the moment due to the high cost of transport to the existing paper mills near Calcutta. The annual yield of bamboos is estimated to about 9 lacs stems.

VI. MISCELLANEOUS PRODUCTS

(*a*) *Medicinal plants.*—The following medicinal plants are known to occur in our forests. The parts of the plants for use as drugs are noted against each.

(1) *Tinospora cordifolia* (*Gulancha*)—stems.

(2) *Holarrhena antidysenterica* (*Kurchi*)—bark.

(3) *Swertia chirata* (*Chirata*) –shoots.
(4) *Alstonia scholaris* (*Chhatiwan*)—bark.
(5) *Justicia adhatoda* (*Vasaka*)—shoot, leaves and roots.
(6) *Asparagus racemosus* (*Satamuli*)—roots.
(7) *Andrographis paniculata* (*Kalmegh*)—leaves and roots.
(8) *Berberis* spp. (*Kesari* or *Daruharidra*)—stem, bark and roots.

But except *gulancha* and possibly *chireta* none is yet known to be available in large quantities. According to some recent reports from the Divisional Forest Officers of North Bengal, 100 mds. of *kurchi* and 5 mds. of air-dry leaves of *vasaka* would be available annually. The figures of available quantities of the other species are not yet known.

(*b*) *Oil Seeds.*—The most important oilseed available in quantity is possibly *simul*. Oil from the seeds of *simul* is now-a-days a constituent of edible oils known as *Vanaspati*. But the collection of *simul* seeds from existing scattered trees of the North Bengal forests is rather laborious and expensive. It is, therefore, doubtful it if would be a commercial proposition at the moment.

(*c*) *Spices.*—The only species available in quantity (40 to 50 mds. of air-dry fruits per year) is long pepper (*Piper longum*) occurring in the Duars and the foot-hills of Kalimpong and Kurseong divisions. The produce is sold by the grant of lease for the collection from a particular area within a specified period.

(*d*) *Vegetable Dyestuffs.*—*Kamal* powder (fruits of *Mallotus phillippinensis*) and *manjita* (roots of *Rubia cordifolia*) are available in North Bengal, but not in commercial quantities.

(*e*) *Grasses.*—These occur in fair abundance in the Duars and Terai forests. The local demand is often greater than the available supply. Thatch is also available in the 24-Parganas Division in small quantities and is in great demand in the locality. The estimated annual yield of thatch in our forest is about 2 lacs of bundles.

Grasses as raw materials for paper—*Phragmites karka* (*Nal*), available in commercial quantities in the Duars and Terai has been considered a very suitable raw material for paper by the Titaghur Paper Mills, but due to the high cost of transport to Calcutta the exploitation of this grass for paper industry is not feasible at the moment. In fact we have to look forward to the establishment of a paper mill in North Bengal for proper utilization of these grasses as well as of bamboos mentioned earlier in this note.

(*f*) (1) *Golpatta.*—*Golpatta* (leaves of *Nipa fruticans*) is available in the 24-Parganas Division in fair quantities, the estimated annual yield being about 96,000 mds. There is a large local demand for these leaves.

(2) *Hantal* (*Phœnix paludosa*) leaves, available in fair quantities in the 24-Parganas Division, have a local demand and are disposed of on permits. The annual yield is about a lac of maunds.

(3) *Gaicha leaves or Kabaipat* (*Phrynium imbricatum*).—This species is found abundantly in the Duars divisions and is in great demand in the locality. The actual figures of annual yield are not available.

(4) *Leaf mould.*—In the hill divisions this produce has a local demand and gives a certain amount of revenue. The annual yield is about 5,000 mds.

(5) *Fodder.*—Fodder in North Bengal includes various grasses, herbs and climbers and very rarely trees. Annually two to three lacs of head-loads of fodder are disposed of on permits from the North Bengal divisions.

(*g*) *Stones, Boulders, Sand and Minerals*.—Stones, boulders and sand are sources of a certain amount of revenue in North Bengal divisions. The local tea gardens, Railways and the Public Works Department are the main consumers of the produce. The estimated annual yield of stones and boulders is 15 to 20 lacs c.ft. and of sand about 25,000 c.ft.

The quarrying of minerals in the reserved forests is governed by special rules under the Revenue Department, under which certain areas are leased out to private parties for a specified period, for the quarrying and collection of specified minerals, for instance the lime quarry at Jainti in the Buxa Division and the coal deposits at Bagrakote in the Kalimpong Division. The revenue is collected through the Deputy Commissioner of the Civil district concerned.

(*h*) *Animals and Animal Products*.—Wild elephants are captured in the foot-hills of Buxa, Jalpaiguri and Kalimpong Divisions by *khedda* operations usually at an interval of two years. The number of elephants in a catch varies from 10 to 25. Elephant tusks and rhino horns are also occasional sources of revenue of the Duars divisions.

Among other animal products the most important one is shells from the 24-Parganas Division. The maximum annual yield is about 75,000 mds. The produce is disposed of on permits.

CONCLUDING REMARKS

Our present activities in minor forest produce are confined to the utilization of those occurring or growing naturally in the forests. We have not yet been able to grow any minor forest produce as a part of our regular programme of regeneration, for want of sufficient forest land at our disposal. The area of the existing reserved forests in our province is only about 9·3% of the total land area, as against a minimum requirement of about 25%. We have, therefore, had to concentrate on the production of timber forests on the existing available area.

It is hoped that with the increase and development of the timber forests, we shall be able to actually grow certain species of plants exclusively or mainly for "minor forest produce", under a regular programme of the Working Plans. With this end in view we have initiated experiments to grow some exotic species of known commercial utility, namely, *Acacia decurrens* as a source of tannin, *Ocimum* species as a source of camphor, *Cinnamomum* spp. as sources of *tejpat*, camphor and cinnamon, *Aleurites* spp. as a source of the tung oil of commerce, etc.

BEEDI LEAF INDUSTRY IN ORISSA

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SUMMARY

In *Beedis* the leaves of *Diospyros melanoxylon* (*Kendu*—Oriya) are almost universally used for wrapping tobacco. *Kendu* is common throughout Orissa. With the increase in popularity of *Beedis* the *Kendu* leaf industry has immensely developed, and in many forest divisions of Orissa it is one of the principal source of revenue. In this article, the reason of *Kendu* leaves being suitable for *Beedi* making, the sale and all aspects of *Kendu* leaf collections has been briefly described.

Introduction.—Cigarettes were introduced to India along with the British rule. It become the fashionable smoke, and replaced the *hookah* the traditional Indian smoke. Cigarettes were costly, and an average Indian could not afford it. The last two World Wars added to the difficulties, during and after which cheaper varieties of cigarettes were not available in the market. There was a necessity for a cheaper substitude for cigarettes and thus the *Beedis* were evolved. Paper was not easily available and was costly, so in *Beedi* leaves were used for wrapping tobacco. Among the leaves those of *Diospyros melanoxylon* were found to be very suitable. With the increase in popularity of *Beedis*, the *Kendu* leaf industry has developed very rapidly in Orissa, a brief survey of which has been made here.

Beedi leaves.—In different parts of India various kinds of leaves are used for making *Beedis*. In Orissa, Bihar, Madhya Pradesh, leaves of *Kendu* (*Diospyros melanoxylon*) are commonly found and they are used locally for *Beedis*[1]. In Madras leaves of *Bauhinia racemosa*, *Bauhinia vahlii* and in Assam leaves of *Castenopsis indica* are used. Burma cherrots are wrapped in leaves of *Careya arborea*, or *Cordia myxa*. In Bengal, Assam and parts of Orissa dried sal leaves are used.

Among all these *Beedi* leaves those of *Kendu* (*Diospyros melanoxylon*) are best for commercial production of *Beedis*. This is due to the suitable size of the leaves, leathery texture, suitable workability when dried, palatability when smoked, and easy availability.

Distribution of Kendu (*Diospyros melanoxylon*) Oriya—*Kendu*, Hindi—*Tendu*, *Kan-Balai*, Telugu—*Trumki*.—This is one of the most characteristic trees of the dry mixed deciduous forests throughout India. It is locally common in sall forests often replacing sal where the ground is too poor to support sal[2]. There are two forms, *D. melanoxylon* and *D. tomentosa*, the main botanical distinction lies in slight difference in leaves. For our purpose we take both the forms as one.

Description of the leaves and the tree[3].—It is a small and bushy or a large straight tree with grey or rusty *tomentose* shoots. Leaves opposite, 4 feet 8 inches, broadly ovate or elliptic. Old coriaceous, *tomentose* to glabrescent beneath. Upper surface shining green. Venation-Unicostate, reticulate. Bark black and rough. Grows to a girth of 7–8 feet in plains forests, and occurs as an associate of sal. Well grown trees yield considerable pieces of black ebony. Poles used in house building. Fruit a globose to ovoid berry, many seeded and delicious. Timber when burnt emits sparks.

Regenerates profusely from root suckers, which makes it difficult to eradicate from waste lands. The leaves are not browsed. Trees are deciduous, new leaves come out from middle of March to May.

Quality of the leaves.—The leaves from bigger trees are not suitable for *Beedi* making as they are tough. It is the small bushes from root suckers that yield most of the *Kendu* leaves for *Beedis*. Leaves are also collected from small trees, but they are never collected from trees having a girth more than 2½ feet.

The leaves of *Kendu* (*D. melanoxylon*) vary a great deal. As far as *Beedi* making is concerned, the texture, venation and relative thickness of the midrib, and the lateral veins are of great importance. The thickness of midrib is of no consequence, as during the *Beedi* making process the leaf is cut into two or more pieces and the midrib is discarded. The thinner the lateral veins the better is the leaf for the purpose of *Beedi* making, and it is this factor, and the leathery texture that determines the quality and price of the leaves.

It has been noticed that the leaves of certain localities have particularly good leathery texture and thinner lateral veins. This may be due to site factors or more probably due to existence of several forms or varieties of the species.

A short history of Beedi leaf Industry in Orissa.—Collection of *Kendu* leaves for *Beedi* making was probably first started in Central Provinces (now Madhya Pradesh). In Orissa it first started in Kolabira Zamidari in Sambalpur District, near about 1926. Among the ex-State areas Sonepur has the place of honour to have fostered the industry from the beginning. It will be interesting to know that during the first year the right of collection was given free to a contractor who approached the Maharajah. During the second year at the persistent request of the contractor about Rs. 100/- was received as annual royalty. Starting with Sambalpur the industry spread to other ex-States and regular divisions of old Orissa. At this time cost of collection, etc., of *Kendu* leaves was about one rupee delivered at the station godown. The sale price was over Rs. 3/- per bag.

With the advent of last World War *Beedis* became very popular and were increasingly used. It is during this time the *Kendu* leaf industry gained a great momentum, and has since established itself on a sound footings.

Method of sale.—In the forest divisions of old Orissa Province the right of collection was sold by public auction. In the ex-State areas the method of sale was by private treaty with the Rulers, where the royalty to be paid was settled by negotiation. Long term leases varying from 3 to 10 years were generally given. The agreement provided for a gradual increase in the consideration money that was to be paid by the contractors. As an example the case of Talcher may be stated. Just before merger the Ruler leased out the right of collection of *Kendu* leaves for five years. The consideration money payable was to be as follows :—

1949	Rs. 10,000
1950	„ 10,500
1951	„ 11,000
1952	„ 11,500
1953	„ 12,000

At the time of merger most of the States had running leases. On examination of consideration money that was to be paid by the contractors, it was found in most cases they were ridiculously low. There was a necessity for raising the royalties. The contractors were also very co-operative and at a conference of Hon'ble Minister in charge and the contractors, the revised rates were settled, and fresh contracts were executed with the contractors.

Organization of the work.—The contractors have to organize and maintain an elaborate organization for the collection of leaves, and it is on the efficiency of this organization, that the

success of a *Kendu* leaf contractor depends. The work is wide-spread and all work is to be done within $2\frac{1}{2}$ to 3 months, April to June.

The area under each contractor is divided into several zones, according to available quantity of leaves, and has no reference to area. Some of the zones may be very small in area and some may be very big. Each zone has an office with a cashier and 2, 3 or more supervisors, who are provided with cycles.

In each zone there are several collecting centres each in charge of a *mohurir*. Collecting centres are grouped together and one group is put in charge of a supervisor.

Each collecting centre has a house which is used as a residence for the *mohurir* if necessary, and as a temporary godown for storing dry leaves. The *mohurir* receives leaves from the collectors daily and makes payment. The *mohurirs* work and accounts are daily checked by supervisors. The contractor himself or his agent checks the accounts and work of the cashier, supervisors and *mohurirs* regularly. A successful *Kendu* leaf contractor is one of the busiest men in the world during the collecting season.

Coppicing.—The first operation before the collection season starts, is coppicing the *Kendu* shrubs. At present coppicing is not done in a large scale. This is due to abundance of *Kendu* leaves, and labour difficulties. It is done only by some contractors in limited areas where there is no dearth of labour. It is done generally in February and mostly small shrubs are coppiced.

Collection.—Collection of *Kendu* leaves starts from end of March or beginning of April and continues till the onset of monsoons, i.e., about 15th or end of June.

Generally women and children are engaged in collection work as they do the work best.

The collectors go out in the morning to the forests or nearby wastes and come back in the afternoon with the days collection. The *mohurir* in charge of the collecting centres receives the leaves, counts them and makes payment. Before delivery at the collecting centres the leaves are to be tied into small bundles of 20–25 each ; the bundle is called a *Bida*. The *mohurir* does not accept loose leaves.

Collection of the leaves is a technique by itself, as the collectors have to select and pluck only the right type of leaves. The leaves must not be very old or very young. If there are faulty leaves the day's collection may be rejected.

According to Orissa *Kendu* leaves (control and distribution) order of 1949, the District Magistrates of the merged districts have to fix the minimum price of *Kendu* leaves to be paid by the contractors to the labourers collecting the leaves. In Dhenkanal District the prices fixed are :—200 leaves per pice for leaves from Government land ; 150 leaves per pice for leaves collected from tenants holdings.

In the ex-State areas of Dhenkanal and Talcher alone nearly 10,000 labourers are engaged daily for collection and other working during the collecting season. Females and children doing collection work earn 6–12 annas per day.

Drying.—After collection the *Bidas* have to be dried. Drying is very important as the quality of the leaves may be reduced due to faulty drying process. Each collecting centre has a drying yard which is just a levelled piece of land without any overhead cover. The *Bidas* are spread in the yard after receiving them from the collectors, and left there for 72 hours with the dorsal side up.

Then the *Bidas* are turned upside down so that the ventral side is up and left as such for 24 hours. After this the *Bidas* are kept sideways for 48 hours, and this completes the drying process.

Collection and drying is done side by side, and all drying has to be finished before the monsoons.

The drying process is rather a wasteful one. Continuous rain for 2 or 3 days spoils the whole lot in the drying yard. A strong wind or storm blows away most of the leaves and these are very common in the pre-monsoon days. 25–30 per cent of the leaves collected are lost during drying.

Temporary storing.—It has been already said that each collecting centre has a house which is used as a temporary godown if necessary. These godowns may also be called forest godowns.

The *Bidas*, after drying, are stored in these temporary godowns till the first shower of monsoon rains. For such storing they make a sort of platform with woodenposts and beams, which is called a *Bhadi*. Over this brushwood and then a layer of straw is spread. On this straw layer the *Bidas* are piled layer after layer.

Packing.—Just after the first shower of monsoon rains the dried leaves became soft and easy to bundle. So it is necessary to wait till the first shower of monsoon rains to do the packing.

The *Bidas* are first tied into big bundles. About 70 to 80 *Bidas* make a bundle and each bundle weighs about 2 seers. These bundles are put in gunny bags and neatly packed. Each bag contains about 30–40 bundles and weighs about 2 mds. Now the *Kendu* leaves are ready for export.

Market.—Only a small portion of the *Kendu* leaves produced in Orissa are used locally. The local *Beedi* making industry consumes at best 15 per cent of the leaves. Sind, East Bengal and Madras are the principal markets for Orissa *Kendu* leaves. The trade agreement between India and Pakistan has given immense relief to the Orissa *Kendu* leaf contractors.

Cost.—Costs of collection, drying, packing, etc., varies. In Dhenkanal Division the costs of collection, drying, packing and carriage comes to about Rs. 35/- per bag at the station godown.

Experiments in Coppicing.—There is great scope to increase the production *Kendu* leaves by coppicing the small *Kendu* bushes and trees. Apart from the quantity, the quality of the leaves obtained from coppiced plants is also better. But the contractors are not very serious at this stage about coppicing, as they get plenty of it even without coppicing.

It can be done in January, if it is intended to do more than one coppicing. Generally it is done during the end of January or first half of February.

Certain rough experiments carried out by the writer gave the following indications :—

Coppiced stumps can produce leaves suitable for plucking within 40–45 days of coppicing. The areas where experiments were carried out were waste lands. Soil was sandy loam with gravel. The coppicing was done on 13th of Feburary 1951.

There is no doubt that the time taken to produce the leaves will vary according to the site and the season. If the coppicing is done earlier the time taken will be more, if done

later the time will be less as by that time we get showers of rain. Acting on this presumption it can be safely said that there can be three pluckings or harvest of leaves from the same area if coppicing is done according to the following time-table instead of the one that is done at present.

1st—Coppicing to be done during 1st week of January. Time likely to be taken to produce leaves suitable for plucking will be about 55–60 days. Harvesting 1st to 15th March.

2nd—Coppicing—15th to 22nd March. Time taken to produce suitable leaves 40–45 days. Harvesting last week of April.

3rd—Coppicing—1st to 7th May. Time likely to be taken to produce suitable leaves 35–45 days. Harvesting 5th to 15th June.

I have discussed this matter with several experienced *Kendu* leaf contractors. They say this is possible and some actually claim to have done two pluckings from the same area by coppicing twice. But they are not able to follow this practice on a larger scale due to dearth of cheap labour.

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VOLUME 78 NUMBER 5

INDIAN FORESTER

MAY, 1952

EDITORIAL NOTES

Ourselves.

The December, 1949 issue of the *Indian Forester* would have been received by our subscribers by now. This completes the arrears in the issue of our magazine. We do not wish to recapitulate once more the circumstances under which we had to fall into arrears, but we do wish to record once again our thanks to the Chairman and Vice-Chairman of our Board of Management but for whose great help we could not have rehabilitated ourselves so quickly. We have cleared our arrear issues, but we are not yet out of the wood regarding finance. May we appeal to our readers to help us with more subscribers and advertisements.

★ ★ ★ ★

Bombay State Forestry Conference 1951.

We are publishing elsewhere an account of the Bombay State Forestry Conference which was held in September, 1951 at Poona, after a lapse of almost 22 years. The value of such conferences, in these days when forestry is coming very much to the fore in the eyes of the public, cannot be minimized. We commend this idea to all other States in India.

★ ★ ★ ★

Deputation of Shri V. D. Limaye, Officer-in-Charge of Timber Mechanics Branch, Forest Research Institute to the First International Timber Grading School at Singapore.

We are happy to announce that Shri V. D. Limaye, Officer-in-Charge, Timber Mechanics Branch at the Forest Research Institute, Dehra Dun, was deputed recently by the Government of India, at the request of the U.N.O., to teach the "Theory and Practice of Grading Teak" to the students of the First International Timber Grading School held recently at Singapore by the F.A.O. in Malaya. A short note on the running of the "Timber Grading School", prepared at our instance, by Shri V. D. Limaye is published elsewhere.

★ ★ ★ ★

Election of Dr. K. R. Nair, Statistician of the Forest Research Institute as a Fellow of the American Statistical Association.

We are glad to learn that Dr. K. R. Nair, Statistician of the Forest Research Institute, who is now in America under the Fulbright exchange visitor programme has been elected a Fellow of the American Statistical Association. The constitution of the Association limits this select group to 150 of the most outstanding persons in the field of Statistics. The citation issued in this connection states that Dr. Nair is 'one of the world's leaders in the construction and properties of incomplete block designs'.

★ ★ ★ ★

Election of Dr. A. Purushotham, Officer-in-Charge, Wood Preservation Branch, Forest Research Institute as a member of the American Wood Preserver's Association and also the American Railway Engineering Association.

We are glad to announce that Dr. A. Purushotham, D.Sc., F. INST. P., Officer-in-Charge, Wood Preservation Branch of the Forest Research Institute, has been elected a member of the American Wood Preserver's Association and also of the American Railway Engineering Association.

V. S. K.

INDIGENOUS CELLULOSIC RAW MATERIALS FOR THE PRODUCTION OF PULP, PAPER AND BOARD

PART IX.—NEWSPRINT GRADE MECHANICAL PULP FROM *STERCULIA CAMPANULATA* (*PAPITA*)

BY R. V. BHAT, M.SC. (TECH.), Ph.D. (BOMBAY), Ph.D. (MANCHESTER), A.R.I.C., A.T.I.
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AND

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SUMMARY

Laboratory experiments on the production of mechanical pulps from *Sterculia campanulata* (*papita*) are described. Standard pulp sheets were prepared from 100% mechanical pulp from this species and from a mixture of 70% mechanical pulp and 30% bamboo bleached chemical pulp. The strength properties of the standard sheets prepared from the mechanical pulp produced under suitable conditions have shown that this wood is a promising raw material for the production of newsprint. The colour of the pulp is also suitable for newsprint. This species is available in the Andamans and the wood is used in the match industry in Calcutta.

INTRODUCTION

Newsprint is a generic term used to describe printing paper of the type generally used in the publication of newspapers. The pulp should satisfy certain conditions in order to be suitable for the manufacture of newsprint. It should be cheap and be capable of running with the minimum addition of costlier pulps on high speed Fourdrinier machines. In use, newsprint should run on high speed rotary printing machines without breaks. It should have good absorbency for the cheap news inks, should be capable of receiving sharp impressions of types and printing plates without blurring, and should be sufficiently white to obtain good contrast and easy reading without straining the eyes. The opacity of the newsprint should be good so that the printing on one side of the paper is not easily discernible from the other side. The paper should be free from fuzz and should be relatively stable dimensionally for good register in colour printing.

These conditions are satisfied by mechanical pulps produced from suitable woods by wet grinding. Because of the high yield and the simplicity of manufacture, mechanical or groundwood pulps are the cheapest to produce. These pulps are also characterized by good opacity, ink absorbency, bulk and softness. Newsprint is manufactured on the widest paper machines (220–320 inches in deckle) and at the highest speeds (800–2,000 feet per minute) of any printing papers in order to bring down the production cost as low as possible. Since mechanical pulps are not strong enough for running on such paper machines, these are mixed with 10–30% of chemical pulp.

In Europe, Canada and America, the mechanical pulp for newsprint is manufactured from coniferous woods such as spruce, fir and hemlock. These woods are eminently suitable for the production of newsprint grade groundwood pulps. In some countries, where conifers do not occur, light coloured woods of broad-leaved species have been successfully utilized for the production of mechanical pulps for newsprint. Poplar in Italy and *Eucalyptus regnans*

in Australia may be quoted as examples. In India, spruce and silver fir occur in the Himalayan regions at altitudes of 8,000–10,000 feet above sea-level. They are found in such rugged and inaccessible terrains that their extraction and transport at economic rates to a suitable manufacturing site are not easy. The problem of their economic utilization for the newsprint industry has been engaging the attention of the Government of India. Woods of broad-leaved species suitable for the production of newsprint grade mechanical pulps are not found in a compact area in this country in sufficient quantities to feed an economic newsprint mill. Hence, India is entirely dependent upon foreign countries for the supply of newsprint. No civilized and democratic country can do without newspapers. India is spending a colossal amount in foreign currency for the purchase of newsprint which is becoming increasingly difficult to obtain even at very high prices. The imports of newsprint into India for the last five years are given in Table I. These values are taken from the "Accounts relating to the Foreign Sea and Air-borne Trade and Navigation of India", Department of Commercial Intelligence and Statistics, Government of India, Calcutta. The figures in column 2 in Table I are correct to the nearest ton.

TABLE I.—*Imports of newsprint into India*

Year From 1st April to 31st March	Quantity in tons	Value in rupees
1947–48	43,935	3,11,55,608
1948–49	57,983	4,37,87,941
1949–50	44,605	2,69,75,567
1950–51	75,206	5,37,13,305
1951*	31,822	3,60,97,933

* The figures are for the first seven months of 1951 from the 1st April 1951.

It has been estimated that the annual consumption of newsprint in this country would increase to 1,00,000 tons by 1956.

In order to explore the possibilities of utilizing fibrous raw materials other than the conifers for the manufacture of newsprint, investigations on light coloured woods of broad-leaved species and bagasse have been undertaken in this Institute. Work carried out in this Institute on *Broussonetia papyrifera* (paper mulberry) has already been published[1]. The Government of India in its general scheme of the utilization of the forest resources of the Anadaman Islands suggested that *Sterculia campanulata* (*papita*) and *Sterculia alata* (*letkok*) should be tested for their suitability for paper pulp. Hence, investigations were undertaken on the production of easy bleaching chemical pulps and of newsprint grade mechanical pulps from *Sterculia campanulata* and *Sterculia alata*. The results of the laboratory experiments on the groundwood pulp from *Sterculia campanulata* are recorded in this bulletin as an interim report.

STERCULIA CAMPANULATA (PAPITA)

Sterculia campanulata, Wall. (*papita*) is a large, tall tree 100–130 feet in height, and 8–10 feet in girth. Its wood is cream in colour but is quickly discoloured with bluish-black fungus staining if not dried immediately after felling and conversion ; once it is dried, it remains in a clean condition indefinitely[2]. The wood is light in weight, 1 cu. ft. (air-dry)

weighing 21–25 lb. The resin content of this wood is low, its alcohol-benzene solubility being 1·48%. This species is found in Lower Burma, Mergui and Tavoy. It is very common in the deciduous forests of the Andamans.

The wood of this tree is used in Calcutta in the match industry for the manufacture of match splints and boxes. The present price of this wood is about Rs. 150 per ton.

THE RAW MATERIAL

Four billets, 8–8·5 feet in length and 14–15 inches in diameter, were supplied by the Chief Conservator of Forests, Andamans. The age of the trees from which these billets were prepared was 30–35 years. The billets were received without the bark. The colour of the wood was cream. Blocks, $8 \times 4 \times 2\frac{1}{2}$ inches, were prepared for the grinding experiments since the pocket of the laboratory grinder could hold such blocks conveniently. These blocks were soaked in water before grinding.

PRODUCTION OF PULP

The laboratory grinder used for grinding this wood has been described in a previous publication[5]. In oder to find out the best grinding conditions, mechanical pulps were prepared under the following grinding variables ; (1) pressure of the wood on the stone ; (2) pit temperature ; (3) speed of the grinding stone ; and (4) sharpness of the stone. In order to get an idea about the sharpness of the stone, a deodar (*Cedrus deodara*) block, $18 \times 8 \times 4$ inches, was ground under a pressure of 10 lb./sq. inch and the time taken for grinding 1 cm. (in height) of the block was noted. The grinding was continued till 4 cm. (in height) of the block was ground, the time taken for grinding each cm. of the wood noted, and the average time taken for grinding 1 cm. of the wood was calculated. The time taken for grinding 1 cm. of the deodar wood was taken as a fair indication of the sharpness of the stone. The surface of the grinding stone was taken as sharp when 1 cm. of the deodar wood was ground in less than 2 minutes. For the grinding experiments recorded in this bulletin the surface of the stone was dull as it took 4 minutes to grind 1 cm. of deodar wood.

The grinding stone was of Hercules make and was of medium grit. The surface of the stone was prepared first by means of a straight-cut burr and then a spiral 10-cut burr was used for dressing the surface. When a spiral 8-cut burr was used, pulps with poor strength properties were obtained. The pressure of the wood on the stone was varied by changing weights as described in the previous publication[5]. Hot water was used for the grinder sprays for getting higher pit temperatures. The speed of the grinding stone was varied by changing the pulley of the driving shaft.

Since mechanical pulps prepared with a sharp stone were characterized by poor strength properties, all the subsequent grinding experiments were carried out with a dull stone. Standard sheets were prepared from 100% mechanical pulp and from a mixture of 70% mechanical pulp and 30% bamboo chemical pulp–beaten and unbeaten–on the sheet machine described in the Second Report of the Pulp Evaluation Committee to the Technical Section of the Paper Makers' Association of Great Britain and Ireland. The drainage time as noted on the sheet machine according to the recommendations made in this Report is recorded in column 3, Table III. The grinding conditions and the screen analysis of the mechanical pulps prepared under the various conditions are given in Table II and the strength properties of standard sheets prepared from 100% mechanical pulp and from a mixture of 70% mechanical pulp and 30% bamboo bleached chemical pulp in Table III. The brightness of standard pulp sheets prepared from these pulps was measured by means of the Photoelectric Reflection Meter Model 610 (Photovolt Corporation, U.S.A.). The results in column 9, Table III, are expressed on the basis of the brightness of magnesium oxide equal to 100.

TABLE II.—*Grinding conditions of Sterculia campanulata and screen analysis of the mechanical pulps*

1	2	3	4	5	6	7	8	9	10	11	12	13
									Screen analysis			
										Retained between		
Serial No.	Moisture in wood	Stone surface condition	Pressure of wood on stone	Peripheral speed of the stone	Pit temperature	Pit consistency	Wood ground per 24 hours (on the oven-dry basis)	Energy consumed per ton of oven-dry wood	Retained on 40-mesh	40 and 120-mesh	120 and 200-mesh	Passing 200-mesh
	%		lb./sq. inch	ft./minute	°C.	%	cwt.	H.P. days	%	%	%	%
1	25	Dull	16·3	3382	27	1·0	4·2	150	57	9	4	30
2	25	,,	27·2	3476	32	1·4	9·4	100	60	11	3	26
3	25	,,	38·0	3456	32	1·7	12·0	77	67	7	2	24
4	50	,,	48·9	3356	33	2·2	14·7	71	73	20	2	5
5	70	,,	38·0	3270	68	1·9	15·0	54	76	10	2	12
6	70	,,	38·0	1968	36	1·6	5·6	92	75	6	2	17

TABLE III.—*Strength properties of standard pulp sheets from mechanical pulps described sheets were conditioned*

1	2	3	4	5	6
Serial No.	Freeness	Drainage time	Basis weight	Breaking length (Schopper)	Stretch
	c.c. (C.S.F.)	seconds	g./sq. metre	metres	%
1*a*	38	85	61·3	3330	2·0
1*b*	58	55	61·0	3760	2·0
2*a*	60	30	59·6	2900	1·3
2*b*	85	24	61·2	2990	1·5
3*a*	120	18	61·8	2750	1·5
3*b*	250	12	59·6	2940	1·7
3*c*	165	16	60·8	2920	1·8
4*a*	157	11	59·3	1910	1·0
4*b*	310	9	58·9	2170	1·5
4*c*	200	10	57·6	2130	1·2
5*a*	280	8	65·4	1950	1·5
5*b*	250	7	63·3	2390	2·0
6*a*	176	16	62·1	2860	1·5
6*b*	260	12	62·8	3000	2·0

* Expressed on the basis of magnesium oxide = 100. The Photoelectric Reflection Meter Model 610 was used for determining the brightness.

in Table II. Serial Nos. in this Table correspond to Serial Nos. in Table II. The pulp at 65% R.H. and 62°F.

7	8	9	10
Tear factor (Marx-Elmendorf)	Burst factor (Ashcroft)	Brightness*	REMARKS
25·1	14·1	59	Sheets from 100% mechanical pulp.
55·2	19·2	59	Sheets from a mixture of 70% mechanical pulp and 30% beaten bamboo bleached pulp of 250 c.c. (C.S.F.) freeness.
23·1	11·2	59	Sheets from 100% mechanical pulp.
50·3	17·2	59	Sheets from a mixture of 70% mechanical pulp and 30% beaten bamboo bleached pulp of 250 c.c. (C.S.F.) freeness.
28·2	11·0	62	Sheets from 100% mechanical pulp.
68·0	16·5	62	Sheets from a mixture of 70% mechanical pulp and 30% of unbeaten bamboo bleached pulp of 650 c.c. (C.S.F.) freeness.
50	18·3	62	Sheets from a mixture of 70% mechanical pulp and 30% beaten bamboo bleached pulp of 250 c.c. (C.S.F.) freeness.
22·2	7·1	56	Sheets from 100% mechanical pulp.
62·1	13·9	58	Sheets from a mixture of 70% mechanical pulp and 30% unbeaten bamboo bleached pulp of 650 c.c. (C.S.F.) freeness.
40·2	15·1	58	Sheets from a mixture of 70% mechanical pulp and 30% beaten bamboo bleached pulp of 250 c.c. (C.S.F.) freeness.
36·0	10·2	57	Sheets from 100% mechanical pulp.
57·1	13·8	58	Sheets from a mixture of 70% mechanical pulp and 30% beaten bamboo pulp of 420 c.c. (C.S.F.) freeness.
42·0	14·4	59	Sheets from 100% mechanical pulp.
74·3	16·7	59	Sheets from a mixture of 70% mechanical pulp and 30% beaten bamboo bleached pulp of 280 c.c. (C.S.F.) freeness.

DISCUSSION

The colour of the mechanical pulp from *Sterculia campanulata* is suitable for newsprint. The brightness of the pulp sheet is about 59. The brightness of foreign newsprint used in the Indian press was also determined and found to be 60.

On comparing the data in Serial Nos. 1–4, Tables II and III, it will be seen that the pocket pressure of 38 lb./sq. inch is most suitable under the conditions studied. On comparing the results of Serial Nos. 3 and 6, Tables II and III, it will be seen that at the pocket pressure of 38 lb./sq. inch the production of the groundwood pulp is less than half when the grinding is carried out at the lower peripheral speed of 1968 ft./min. instead of 3,456 ft./min. There is no appreciable difference between the strength properties of the pulps prepared under these two conditions except in the case of tear value which is higher in the case of the pulp prepared at a lower peripheral speed of the grinding stone. The results of Serial Nos. 3 and 5, Tables II and III, show that higher pit temperature of 68°C. helps in getting a higher production of pulp and consequently the power consumption per ton of pulp is lower. At the higher temperature the breaking length of the mechanical pulp is lower and the tear value higher. Under the conditions studied, the grinding conditions recorded in Serial No. 3 are the best.

With increase in the pocket pressure, the production of the groundwood pulp increases with a consequent decrease in the energy consumption per ton of pulp, and the pulp becomes more free and hence suitable for running on a high speed paper machine. There is a decrease in the strength properties of the pulps with increase in the pocket pressure but the drainage time of the groundwood pulps prepared with the pocket pressures of 16·3 and 27·2 lb./sq. inch is so high that they may not be suitable for the production of newsprint on high speed machines. Besides, the cost of their production is prohibitive because of the very low outturn. The pulp becomes coarser with increase in the pocket pressure used for grinding. When the pocket pressure is increased above 38·0 lb./sq. inch, the strength properties of the pulp are so low that the pulp may not be suitable for newsprint. Under the conditions of the stone, burr and the surface used in these experiments, the pocket pressure of 38·0 lb./sq. inch is the best for grinding the wood of *Sterculia campanulata*.

The addition of bamboo bleached chemical pulp to the extent of 30% to the groundwood pulp from *Sterculia campanulata* helps to improve the strength properties. The results recorded in Table III show that there is no special advantage in beating the bamboo pulp before mixing with the mechanical pulp. The tear of the resultant pulp sheet is better if unbeaten chemical pulp is added.

CONCLUSIONS

1. The colour of the mechanical pulp from the wood of *Sterculia campanulata* is suitable for newsprint.

2. By employing suitable grinding conditions, mechanical pulp suitable for newsprint can be prepared from *Sterculia campanulata*.

3. The addition of 30% of bamboo bleached chemical pulp to the mechanical pulp from this wood improves the strength properties of the resultant paper. It is not necessary to beat the chemical pulp for this purpose.

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SILVICULTURE AS PRACTISED IN THE NORTHERN CIRCLE, WEST BENGAL AND THE PART IT PLAYS IN THE "GROW MORE FOOD CAMPAIGN"

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The forests of the Northern Circle, under the control of this Directorate cover an area of 1,000 square miles lying within the Civil Districts of Darjeeling and Jalpaiguri*. The formation, regeneration and tending of these forests until they become ripe for the axe (i.e., the Silviculture as practised) cover several systems as seen from the table below :

Silvicultural system	Area in sq. miles	Percentage of the total area
1. Clearfelling followed by artificial restocking ..	497	49·7
2. Selection *cum* improvement fellings ..	393	39·3
3. Simple coppice	12	1·2
4. Protection forests with no regular prescription	98	9·8
	1,000	100·0

For the purpose of the subject matter of this note the system of "Clearfelling followed by artificial restocking" only plays an important role, the others do not come within the picture at all. Under this system a total area of 2,176 acres were regenerated and a further area of 2,536 acres were clearfelled and taken up for regeneration during the year 1949–50. The total area prescribed for clearfelling annually is 3,152 acres. Therefore, only 80 per cent of the area prescribed was done, the principal limiting factor being the long-standing problem of paucity of labour in the forest areas. There are only 2,523 houses of labourers spread over 160 scattered villages within the forests.

The practice of growing field crops for one or two years after clearfelling, along with the raising of the tree crops in these areas, known as *taungya* cultivation, can play a very significant part in the Grow More Food Campaign. Taking an average of 2,500 acres as the annual clearfelling area, the maximum possibility at present is more or less 5,000 acres over which the labourers may grow important field crops not only for the purpose of raising vegetables, cotton, spices and oil-seeds, but also for the multiplication of improved varieties of seeds of various cereals and potatoes. Cereals are grown extensively and some potatoes are also grown in suitable areas for the villagers' own consumption as well as for sale of the surplus above their own requirements.

From the following figures of acreage yields of some of the crops raised in these areas an idea of the possibilities may be formed.

	mds.		
(*a*) Maize ..	10–15	1st year.	
	15–23	do.	In twice cropped areas.
	8–10	2nd year.	
(*b*) Paddy ..	10–15	1st year only.	(*Boro* paddy).
(*c*) Potatoes ..	50–75	do.	(Hills).
(*d*) *Dal* ..	5– 6	do.	(Plains).
(*e*) Tapioca ..	10–13	do.	do.
(*f*) Cotton ..	2– 3	do.	do.

Note :—These crops are seldom cultivated all over, each labourer putting various crops on his allotted area.

* *N.B.*—This note was written before the merger of Cooch Behar with West Bengal.

Considering the importance of potatoes as a food crop and their special significance to the country, where there is a growing deficit in cereals, it would be a great advantage if their production could be increased. More potatoes in the country would release the pressure on cereals. It is possible to increase the area and acreage of yield of potatoes in the country, but the main obstacle to be overcome, I believe, is the lack of good quality disease-free seed in sufficient quantity. There is not sufficient suitable area in the hill forests to provide for a very large quantity of seed for the areas in the plains. But the entire suitable available area could be utilized for the multiplication of improved and certified varieties of seeds.

It may seem strange that a forest officer should advocate the growing of potatoes and cereals. But any one conversant with the present economic condition of our labourers cannot but agree that ways and means will have to be found to keep the existing labourers and to attract newcomers in the forests. This can be done only by creating suitable living conditions and providing all possible means for increased earnings by this section of the population. Provisions for better housing, improved water supply and health measures are not enough to attract men to take up hard work in these outlying forests ; improved ways and means of earning maximum income from the land allotted to them are equally necessary.

It has been found on an examination of the figures of cash earnings from this Directorate during the last 3 years that a sum of Rs. 51-3-11 per house of labourer was the annual average (Rs. 1,29,294 by 2,523 houses). The labourers, of course, grow all the food crops they require for their own consumption. The increased wages and earnings by labourers in the neighbouring industrial concerns are attracting the best available men, whereas this Directorate cannot get the right type of men. It is anticipated that by raising cash crops of high market value (viz., jute seeds, potatoes, etc.). in addition to their own food crops, these earnings can be very much increased.

The other alternative is to pay very much higher wages with the consequent repercussion on the cost of formation of our plantations. I cannot advocate adopting such a course.

On the basis of one acre of new plantation per house of labour we are still short by 31%. This deficit is to be made good to enable us to work up to the prescribed limit of 3,152 acres. In addition, there are 60,352 acres of older plantations (up to 1949–50). Labour is required to tend these. With the labour force at our disposal (2,523 houses) an additional area of about 24 acres has to be tended by each house. It has been found by experience that 2 acres of young plantation plus 24 acres of older plantation, i.e., a total of 26 acres of plantation cannot be adequately tended by one house of labourers. As such the requirement of additional labourers is much more than 31%. Perhaps a requirement of hundred per cent increase on the present labour force would not be an over-estimate.

Lastly this note would remain incomplete without a word on the proposed system of marketing of the villagers' crops in future. I would strongly advocate the formation of multipurpose co-operative societies in all Divisions at a very early date. In fact, the matter has already been engaging the attention of the Divisional Forest Officers of those Divisions where this has not yet been established. The advantages, though well known, may be briefly stated here—

(i) to keep out money lenders from the Forest Villages ;
(ii) to provide credit facilities when required by Forest Villagers at a reasonable rate of interest ;
(iii) to enable Forest Villagers to sell the surplus agricultural produce of their fields at a reasonable price :
(iv) to enable Forest Villagers to earn a dividend on their share capital ;
(v) to act as a check on the extravagant habits of the Forest Villagers.

There are difficulties to be overcome no doubt, but I do not consider that with earnestness, zeal and effort by those in authority these cannot be obviated.

AN IMPRESSION OF THE PRESENT STATE OF THE GAME OF THE DHAOLADHAR RANGE, THE UPPER KULU VALLEY AND THE PARBATI VALLEY

BY M. A. WYNTER-BLYTH, M.A., F.R.E.S.

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For any game survey to be authoritative it is necessary to live for a considerable period in the survey area. Therefore, the following remarks should be viewed as an "impression" as they cannot pretend to be an exact survey.

I originally intended to cover the area along the Hindustan–Tibet Road from Narkanda to Wangtu (following the Upper Link Road) and then to survey the Baspa valley, and the Charang valley on the other side of the Indian Kailas range (e.g., the Raldang range).

However, an injury to my left foot made me modify these plans and I covered the length of the Dhaoladhar range from the Sungri–Darunghati area to Aut on the Beas, and, later, the upper valley of the Beas and the middle and lower Parbati valley.

I. THE DHAOLADHAR RANGE

This range is rich in game in the Sungri–Bahli–Taklech–Darunghati–Hansbeshan area, but further north-west, though the species to be encountered are the same, they are less abundant.

Here attention should be drawn to the fact that the term "abundant" is relative ; game is never as abundant on the high hills as in a rich jungle in the plains or in the foot-hills or in the hills of the Peninsula. The difficulties of survival during the winters may be the cause of this.

Small Game.—In the forests above 7,000 feet pheasants are common, especially *kalij* (*Gennæus hamiltoni*) known locally as *jungli murgha* from their great likeness (when on the ground) to the domestic fowl. Both *koklas* (*Ceriornis macropholus*) and *cheer* (*Catreus wallichii*) are also found, and *monal* (*Lophophorus impejanus*) are common above 9,000 feet (lower, of course, in the winter). Black partridge (*Francolinus francolinus*) as always, are in plenty below 8,000 feet wherever there is cultivation, and *chukor* (*Alectoris greaca*) are met with on the open and scrubby hill-sides, the slopes to the north of the Nogli Ghad below Darunghati being noted for them. *Tragopan*, or western horned pheasant, (*Tragopan melanocephala*) are certainly very rare, if, indeed, they are to be found at all, for I could get no information about these birds until I arrived in Kulu, where Jija Rana (to use the hillmen's name), is not so very uncommon. Nor could I collect any information about the snowcock (*Tetrogallus himalayensis*), but, as it is to be found above the Baspa valley, it may well be present on the high slopes of Hansbeshan.

Big Game.—Seven species of big game are to be found in the area.

(i) Black bear (*Selenarctos thibetanus*) are not rare in the thick forests above 8,000 feet, though they descend lower than this in the winter.

(ii) Panther (*Panthera pardus*) are generally scarce but may be found as high as 8,000 feet or 9,000 feet. They are, however, common along the main trade route between Sarahan and Wangtu where they prey on the herds of sheep and goats as they pass to and from their summer pastures.

(iii) *Kakkar*, or barking deer (*Muntiacus muntjac*) are common in forest to 6,000 feet.

(iv) *Goral* (*Nemorhadus goral*) are fairly abundant in steep and rocky country to 8,000 feet.

(v) *Tahr* (*Hemitragus jemlahicus*) inhabit forbidding crags below the snow line (the country at the head of the Nogli valley above Takleeh harbouring some fine heads).

(vi) Musk deer (*Moschus moschiferus*) are found in small numbers at high elevations, and occasionally lower (down to, say, 8,500 feet) as far away from the big hills as Narkanda and beyond.

(vii) Serow (*Capricornus sumatrænsis*), locally named "emmoo", scarce animals throughout the north-west Himalaya, are occasionally met with in the thick cover of remote *nalas* above 7,000 feet.

Red bear (*Ursus arctos*), snow leopard (*Uncia uncia*), ibex (*Capra siberica*), here called "skin", and *bharal* (*Sendois nahoor*) do not seem to be found on the south side of the Sutlej any nearer than the mountains above the Baspa valley.

II. THE UPPER KULU AND PARBATI VALLEYS

Small Game.—The *Tragopan* is found, though in no large numbers. Of the other pheasants the *monal* is distinctly common and appears to be much the most abundant of the tribe (though this may be a false impression as I was in Kulu during the nesting season when *monal* mainly inhabit more open forest close to the tree-line and so are more easily disturbed than the other species which nest in lower, thicker forest).

Snowcock are found in small numbers above 12,000 feet *chukor* are abundant on open and scrubby hill-sides, while black partridge are, as usual, common at low elevation were there is cultivation.

Big Game.—This area differs from that previously discussed in that it is much richer in species, ten or eleven being found.

(i) Black Bear.—Undoubtedly common and it is seldom that one fails to find traces of them during a walk through any secluded forest.

(ii) Red Bear.—These are in small numbers, living at a considerable altitude in the summer, but descending lower in the winter. I came across the tracks of one on the Hamta Pass between 13,000 feet and 14,000 feet. Because the hind feet are always placed on the front foot-marks the tracks give the impression that they have been made by some huge bi-ped...hence the legend of the Abominable Snowman.

(iii) Panther.—Reputed to be quite common in the Kulu valley, but I was not able to get any accurate information about them. By plains standards probably rather scarce.

(iv) Snow leopard.—Scarce, but occasionally recorded at Manali and other places in the winter. One was shot near the village last April and one was recorded beyond the Rhotang Pass in early June.

(v) Ibex (here called *Tangrol*).—Apparently not uncommon. Several were recorded during my stay (May–June).

(vi) *Bharal.*—Less frequently seen than ibex, but like ibex their heads are a favourite temple decoration, and there is no reason to think them very scarce.

(vii) *Tahr.*—In small numbers in difficult country. They descend lower than ibex or *bharal.*

(viii) Musk deer.—Not common. We saw one.

(ix) *Serow* (here called *yamu*).—The same remarks apply here as given for the Dhaoladhar range.

(x) The wolf (*Canis lupus*).—Reputed to come over from Lahoul occasionally in the winter.

The antlers of the Kashmir stag (*Cervus kashmiriensis*) are another popular temple decoration. Local *shikaris* insist that these come from Kangra, which, if true, is very interesting as all books limit the distribution of this animal to Kashmir.

I have no record that *kakkar* are found in this area.

III. CONCLUSIONS

As to the future of the game of these high hills it is pleasant, in these days, when the game of India is fast vanishing from so many parts of the sub-continent, to be able to state that it seems in little danger from man.

One does not have to seek far for the cause. Shooting in this type of country is so exceedingly arduous that it is only likely to appeal to the real sportsman. These who are decimating the game of the plains and foot-hills do not fall into this category. Above all such country is out of reach of the *"sportsman" in the jeep*, that evil combination which, irrespective of game laws and close seasons, slaughters thousands of our fauna and wounds even more. For this latter reason alone I can confidently consider the game of these regions safe...at any rate until man's ingenuity has invented some infernal machine that can climb almost vertical hill-sides and scale precipices to harry ibex and *bharal* and red bear on their native mountain tops.

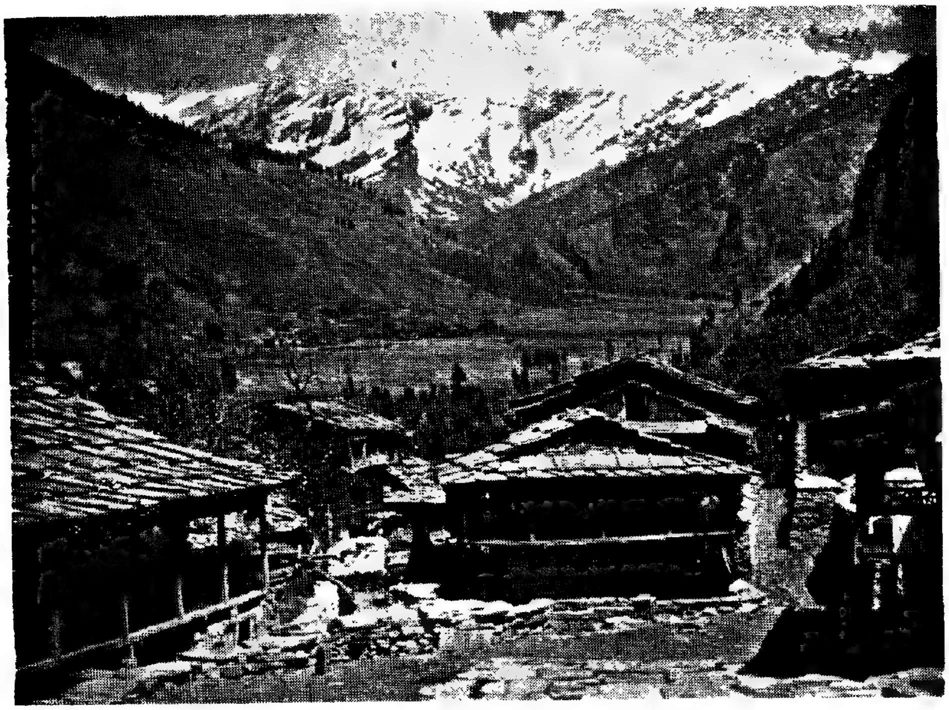
Indeed at the moment it seems almost as if there is too little shooting of the predatory species of game, for a reliable informant in Kulu insisted that these had increased in numbers in recent years causing a corresponding decrease in other sorts of game (i.e., the ungulates).

It must not, however, be thought that I have discovered an unnatural paradise where poaching is unknown. Far from it ! On the contrary I should say that the incidence of potential poachers is very high indeed.

One of the advantages of a non-official conducting investigations of this sort is that he can hear much that is not for official ears. The hillmen are not reticent and I certainly found this to be so. Almost without exception they have an intense interest in sport and a very sound knowledge of the habits of local game, so who can blame them for supplementing their meagre food supplies with the occasional pheasant or *kakkar* in a region where the isolation of the villages and difficulties of the country make it impossible to enforce the game laws with any measure of success ? My rifle and shotgun always aroused great interest and

nearly always a request that we go out shooting at the earliest possible moment, regardless of whether I had a licence, or whether what they wished to shoot was in season or not. However, they themselves possess so few guns (and for those who possess breech-loaders cartridges are so difficult to obtain) and so thick is the terrain that what they do shoot (or trap) can really cause little harm to the general stock. These remarks, of course, refer in the main only to small game. With the big game found at high altitudes the position is different. Few of these can ordinarily be shot without a rifle (hill game being, I do not know why, much more shy than the game of the plains), a weapon that the hillman naturally does not possess, and in addition they are protected by the great difficulties of the type of country they inhabit. I am certain that the poaching of these animals is on the whole negligible. Musk deer, notwithstanding, the killing of which is entirely prohibited, are frequently shot for the valuable musk pouch.

An interesting sidelight on the difficulties of shooting game in the high hills was provided at Pulga in the Parbati valley, a rich game area and an ideal centre for such sport. A very ancient *shikari* showed me his testimonials dating from the earliest years of the century. He had taken out many people almost all of whom had seen ibex, or *bharal*, or red bear or *tahr*, except one irritated individual who wrote that he had failed to see "any buck", but how few had shot anything at all.

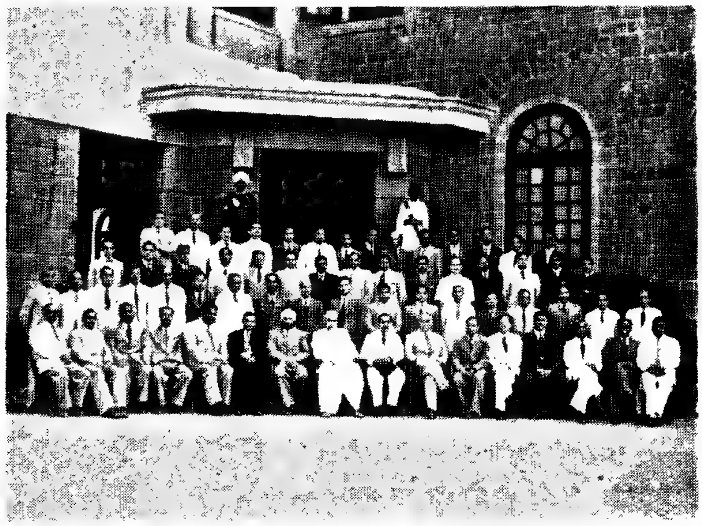


The Upper Kulu valley from Bashist.

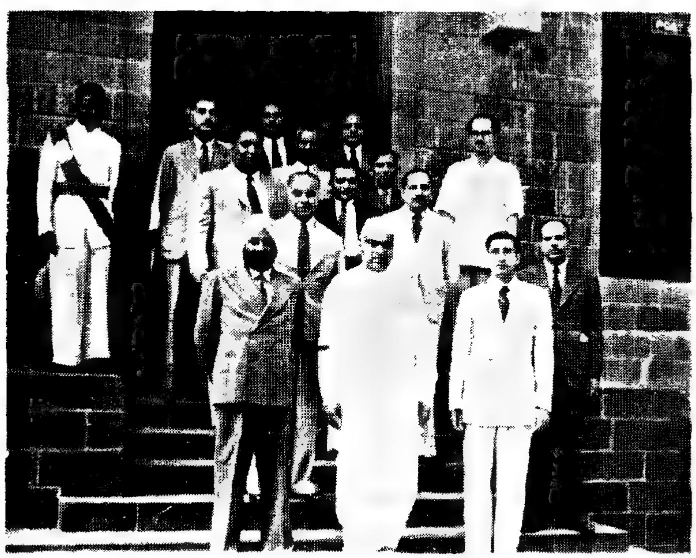
Hamta Pass and Chhatoru Peak 18,314 ft.

Lahoul from the Hamta Pass 14,050 ft.

Hamta Nala Crags that are the haunt of Ibex.



Group photograph of Officers with the Hon'ble Minister Shri M. P. Patil (*in the centre*).



The Hon'ble Minister Shri M. P. Patil being led to the Assembly Hall of the Nowrosjee Wadia College, Poona, for the inauguration of the Bombay State Forestry Conference, 1951.
Left—Shri G. S. Singh, Chief Conservator of Forests, B.S.
Right—Shri I. M. Qureshi, Secretary of the Conference.

THE BOMBAY STATE FORESTRY CONFERENCE, 1951

BY I. M. QURESHI, B.SC. (DIST.), A.I.F.C., B.F.S.
Silviculturist, Bombay State, and Secretary of the Conference

It is said that patience and perseverance seldom go unheeded and a good cause is always rewarded. This was actually the case with the Bombay State Forestry Conference in reviving itself after a lapse of almost 22 long years. The last such Conference was held in 1929 after which it was almost forgotten for many reasons, the work in connection with the last war and then the Independence being the main subjects of attention. This was, therefore, the first Forestry Conference in Bombay State after our cherished independence, and, naturally the interest and enthusiasm with which it was organized can well be imagined. Thanks to the untiring efforts of our Chief Conservator of Forests, Shri G. S. Singh, that Government accepted his proposal to allow the Forest Officers of the State to meet together officially for the discussion of problems of common interest, both technical and administrative, and exchange of views emanating from practical experience in the field, in a free, frank and informal atmosphere. This also afforded a valuable opportunity to the members of the Service to build up Social contacts with those some, whom we would have never met in life ! It also made it possible for the Head of the Department to address the entire corps of his officers in a body on matters which can hardly be discussed through routine official correspondence. The Conference was held from 16th to 19th September, 1951 and sixty-two Officers attended the Conference as seen in the accompanying photograph.

2. The Conference was convened at a very short notice and all the arrangements for its deliberations, out door excursions, and visits to various museums, laboratories and industrial concerns using forest produce, in and around Poona, had to be hurried through. The prompt response and unflinching help given by various institutions that we visited during the course of the Conference, therefore, deserve compliments and thanks for the trouble they took to accommodate our programmes at almost a moment's notice. Special mention requires to be made of the keen interest evinced by our Agriculture and Forest Minister, the Hon'ble Shri M. P. Patil, who inspite of his indisposition and multifarious preoccupations made it convenient to inaugurate the Conference on the morning of the 17th September, 1951. His speech was not only a source of inspiration and encouragement to us but also an illustrious indication of the love he has for forestry.

3. Many of the Officers attending the Conference had only now the first opportunity to meet the Hon'ble Minister and listen to the words of wisdom and advice. The Hon'ble Minister eloquently outlined the broad principles of the policy of the Government in regard to the management of Forest, their exploitation, utilization and conservation. He exhorted the audience to bear in mind the golden principles that forestry stands for and to carry them out faithfully and loyally. He laid particular stress on the establishment, growth and promotion of the Forest Labourers' Co-operative Societies whose cause the Government of Bombay was the first to champion. He illustrated how forests could also contribute to the establishment of some significant cottage industries that would prove a boon to the cultivators. The Hon'ble Minister expressed satisfaction that almost every subject that required attention had been covered by the elaborate agenda awaiting the Conference and hoped that the Conference would certainly yield invaluable results in the form of better understanding and implementation of the intentions of the Government for an improved and sound administration of our forests—the national heritage on which hinges the improvement of the agriculture and the prosperity of the peasant.

4. A very crowded programme awaited the Conference for which a short period of 4 days appeared utterly inadequate. However, the Conference managed to discuss many items on the agenda, though it is admitted that full justice could not be done to some of these. The Chief Conservator wound up the discussion on various problems. The following subjects, *inter alia*, were discussed :—

> (1) Co-operative Societies; (2) Amendment to Sec. 35 of the Indian Forest Act and the Management of Zamindari and Private Forests; (3) Fire Protection; (4) Tending, Regeneration and Afforestation; (5) Industrial wood plantations; (6) Utilization of indigenous woods; (7) Cultivation of forest drug plants; (8) Plantations of special utility timbers; (9) Grazing and fodder; (10) Revision of Working Plans; (11) Forest and Cottage Industries; (12) Forest Roads and Communications; (13) Collection and Utilization of minor forest produce, and (14) Soil Conservation, anti-erosion works and control of spread of aridity.

5. Free and frank discussions were held on these subjects. It was a matter of great satisfaction that inspite of the very short notice and time given to the members for preparing themselves for the Conference, the response and the active part taken by them in the discussions bore an eloquent testimony to the success of the Conference. Liveliness marked the entire proceedings from beginning to the end inspite of the prolonged sitting from 9 a.m. to 6 p.m. excluding presence at the documentary films at night.

6. Excursions to the National Chemical Laboratory of India, Poona; the Meteorological Observatories, Poona; Geological, Soils and other Museums in the Agricultural College, Poona; Bharat Pencils Ltd., Poona; and the Lord Reay Industrial Museum, Poona were of great educative value. Utilization of oil-seeds such as *Mallotus philippinensis* interested the Officers at the National Chemical Laboratories, Poona. The Agricultural Section of the Meteorological Observatories, particularly dealing with the instruments devised for measurement of climatic and atmospheric variations, including transpiration from crops, soil-moisture, humidity, etc., were of great interest to us as forest officers. At the Agricultural College, fibres from Jute and other Jute substitutes grown by the Bombay Forest Department in the forest areas and the Agricultural Department on cultivated lands gave a comparative idea of the lead given and success achieved by the Forest Department in the cultivation of Jute as an inter-crop with teak in forest plantations. Prof. L. S. S. Kumar, Principal of the Agriculture College, Poona, and who is also Economic Botanist to Government had kindly made special arrangements to show their grass-breeding works and the use of cytogenetic methods in evolving desirable genotypes in economic crops. We had also the benefit of hearing Prof. Kumar on grazing problem, Dr. S. Solomon on the use of hormones and auxines as weedicides and Dr. S. W. Mensinkai on the cultivation of fibrous plants. The Bharat Pencils Ltd., gave us an opportunity to realize the practical difficulties and requirements in the selection of a suitable wood for pencil manufacture and kept us searching our forests for giving them something that they wanted. The Lord Reay Industrial Museum, where many of the specimens and exhibits have been supplied by the Forest Department, displayed a variety of useful works being done by the authorities and in which Forest Department is usually called upon for co-operation and help.

7. In the evening, a very entertaining and amusing item was the exhibition of Foreign and Indian documentary films on Shikar, travel and forestry that were kindly loaned by the British Information Service, the U.S.A. Information Bureau, the Bombay Natural History Society and the Maharaj Kumar Dharamkumarsinghji of Bhavnagar. Shri Dharamkumarsinghji was specially kind to come personally to Poona to display his films on Shikar taken by him in Saurashtra.

8. It is not necessary to enumerate the various direct and indirect benefits that have accrued from this Conference for these are only too obvious. However, it appears appropriate to name one or two which are likely to be under-rated. The Conference for example gave a rare opportunity to Junior Officers to understand and appreciate various difficulties that would confront them in the profession they have just entered. To be fore-warned is to be fore-armed. A professional forester has to fight in a three-cornered arena—the public, the Government and above all the biological entity called the "Forests" with complex and varied phenomena. The experience gained by discourse with more experienced fellow-officers is of no less importance than the close contact established between various members of the Service. Direct personal contact is of immense value in creating a mutual understanding that is so very necessary in developing an *espirit de corps* so that officers may communicate with and consult one another for administrative enlightenment or technical opinion.

9. Shri M. D. Bhat, I.C.S., the Chief Secretary of Bombay Government very kindly had an informal talk with the members of the Bombay Forest Service. This was a unique privilege to us to listen to "one of the most noble persons", as the Chief Conservator put it, with over 30 years of meritorious service. Shri Bhat depicted in brief the basic principles that should be the loadstar to every Government servant, and illustrated them, whenever possible, by his own personal experience. As an elder interested in the welfare and prosperity of his services, he naturally offered an opportunity to the members present to put forth their suggestions, if any, to effect improvement in the administration of which he is the ace.

Amidst three loud hearty cheers for Shri M. D. Bhat, the Chief Secretary to Government, followed by three cheers to Shri G. S. Singh, the Chief Conservator of Forests, the Forest Officers dispersed back to their jungles.

WEATHERING TRIALS ON SOME SYNTHETIC RESIN BONDED AIRCRAFT COMPONENTS

BY D. NARAYANAMURTI, JOSEPH GEORGE, N. SUBRAMANYAN AND N. R. DAS
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In an earlier paper (Narayanamurti *et al* 1951) results of weathering trials on several aircraft wings carried out at Dehra Dun and Cochin were described. The present note deals with tests on some resin bonded components carried out subsequently at Dehra Dun.

EXPERIMENTAL

Components Installed.—The components installed for tests were : one section of Mosquito fuselage (bulkhead), aluminium painted, pointing North, Horsa tailplane with fin (aluminium painted, leading edge facing south), part of Horsa mainplane (aluminium painted, leading edge facing south), and section of Hornet wing.

The aerofoils were fixed (on trestles) at normal height, angle of incidence, and dihedral assumed when the aircraft is picketed on the ground.

The condition of the components as received was good. Temperature and moisture conditions were all observed in the same manner as described in the earlier paper.

The locations for the thermocouples and moisture specimens are indicated in Figs. 1 to 4.

Schedule of Observations.—The following schedule of observations was adopted. Excepting on holidays and rainy days temperature and moisture readings were taken once every day ; *viz.*, at 11 a.m. On Thursdays, however, readings were taken every hour.

RESULTS

Meteorological data for the period are given in Figs. 5 and 6.

Temperature.—Some typical results of temperature measurements are represented in Figs. 7 to 10. The calibration curve is given in Fig. 11. From these figures the variation of temperature as affected by type of component, location and season can be seen. The highest temperature, 77 ·4°C. was recorded in location 1 (top) of Mosquito fuselage on 16–4–47 closely followed by 77 ·0°C. in location 3 (top) of Horsa tailplane on 30–7–46. The highest temperature recorded in the Horsa mainplane was 70 ·4°C. in location 1 (top) on 5–7–46. The highest temperatures for the bottom surfaces were 53 ·0°C. for the Horsa mainplane at location 1 on 5–6–46, 49 ·5°C. for the Mosquito fuselage at location 2 on 5–6–46 and 65 ·2°C. for the Horsa tailplane in location 2 on 5–6–46. In the Horsa tailplane generally the tip facing east had a higher temperature than the one facing west. The fin had comparatively lower temperatures and usually location 7 in the fin showed the lowest temperature, the other two locations being about the same.

The area under the curves above 60°C. can be taken as an index of the severity of conditions prevailing in the components. These are assembled together in Table I.

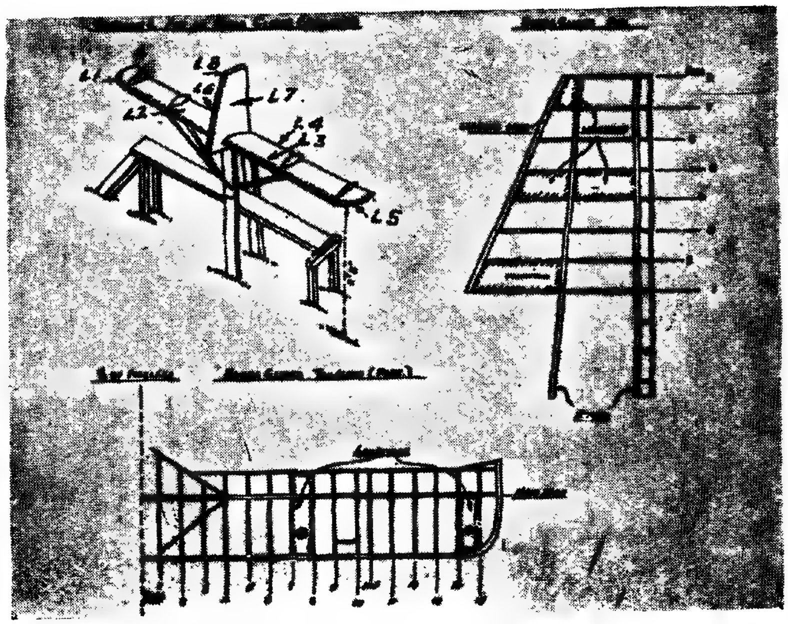

FIG. 1.—Locations of thermocouples and moisture specimens in Horsa tailplane.

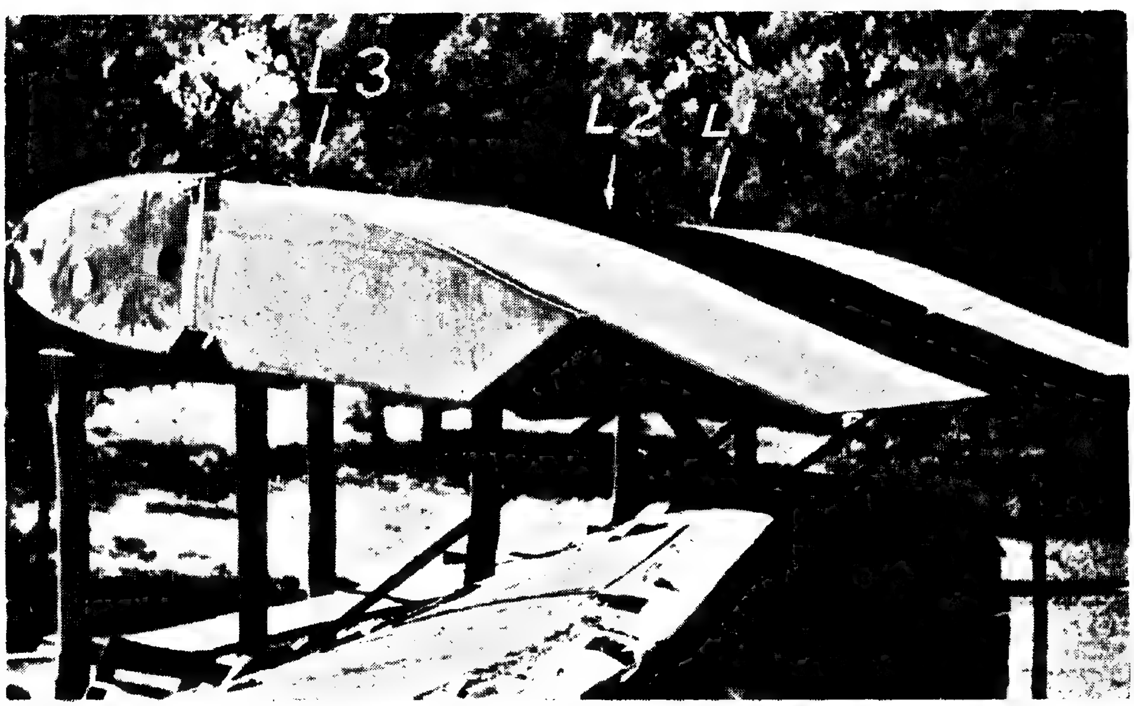

FIG. 2.—Locations of thermocouples and moisture specimens in Horsa mainplane.

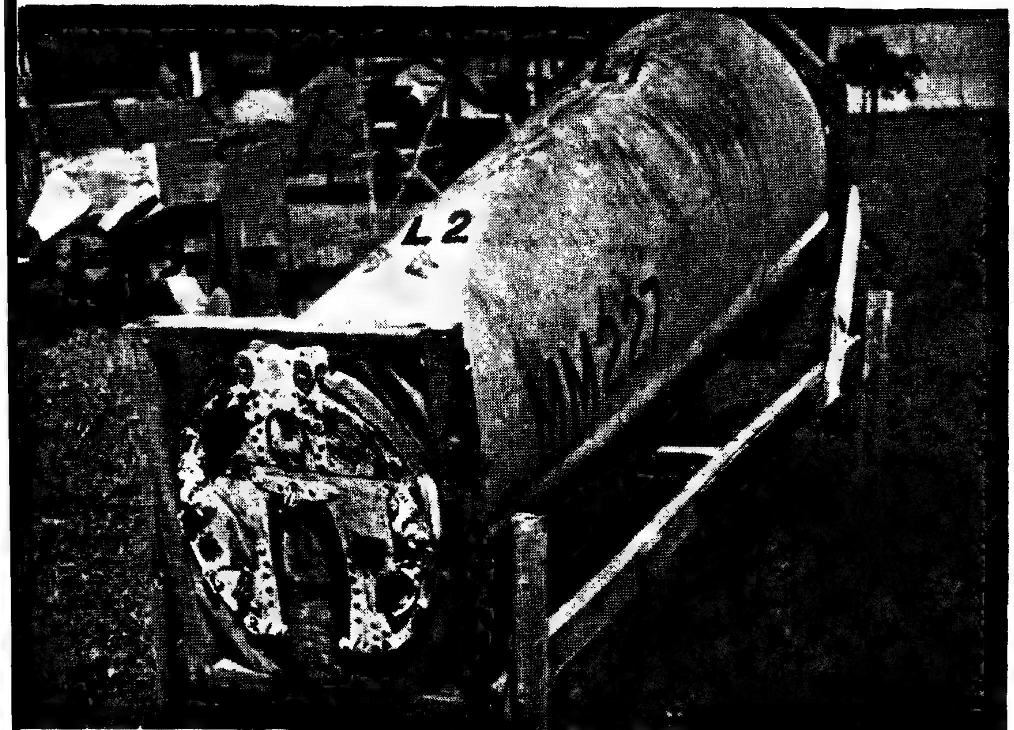

FIG. 3. Locations of thermocouples in Mosquito fuselage.

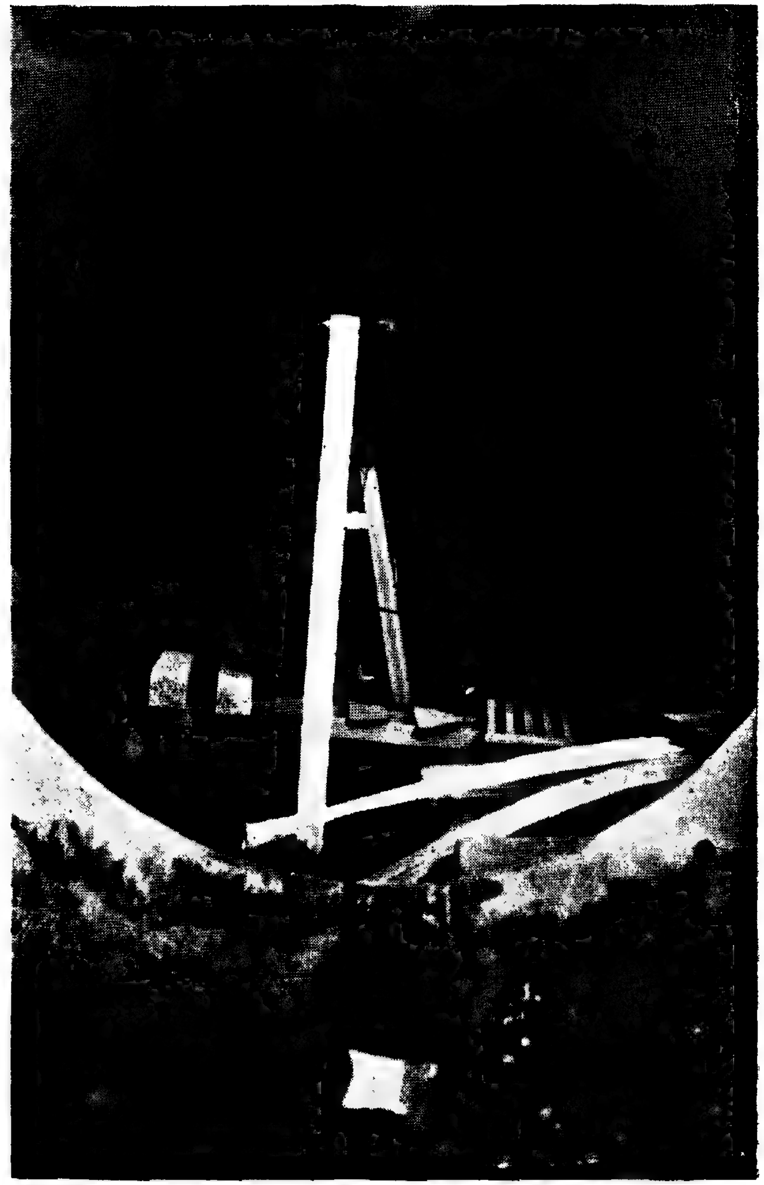

FIG. 4.—Interior view of Mosquito fuselage showing positions of thermocouples and moisture specimens.

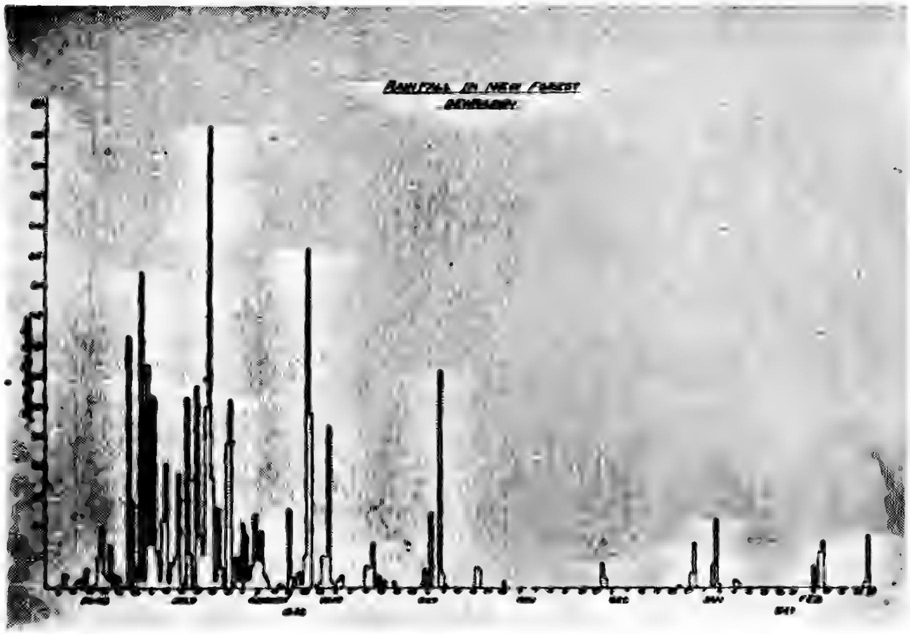

FIG. 5.—Rainfall in New Forest, Dehra Dun 1946–1947.

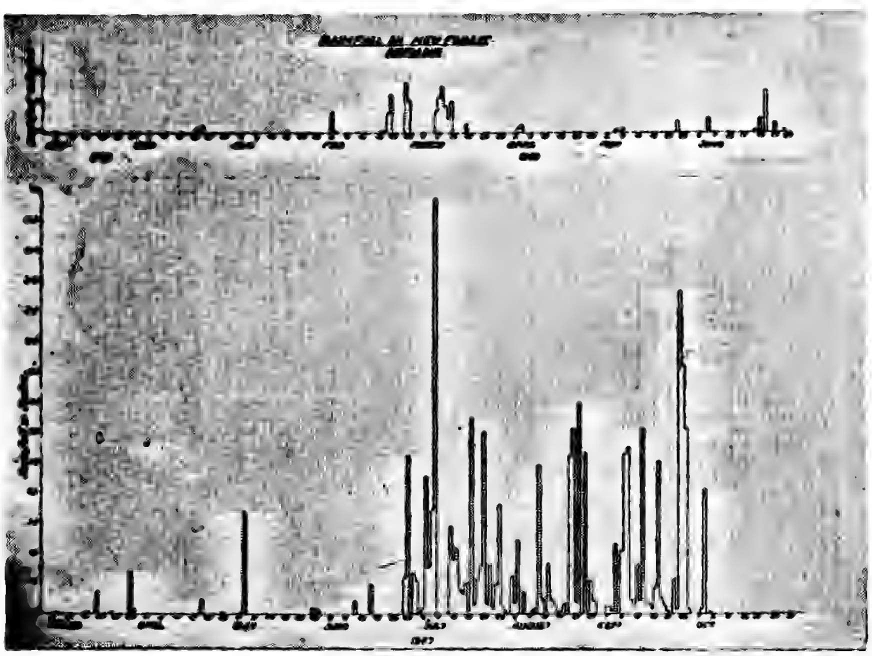

FIG. 6.—Rainfall in New Forest, Dehra Dun 1947–1948.

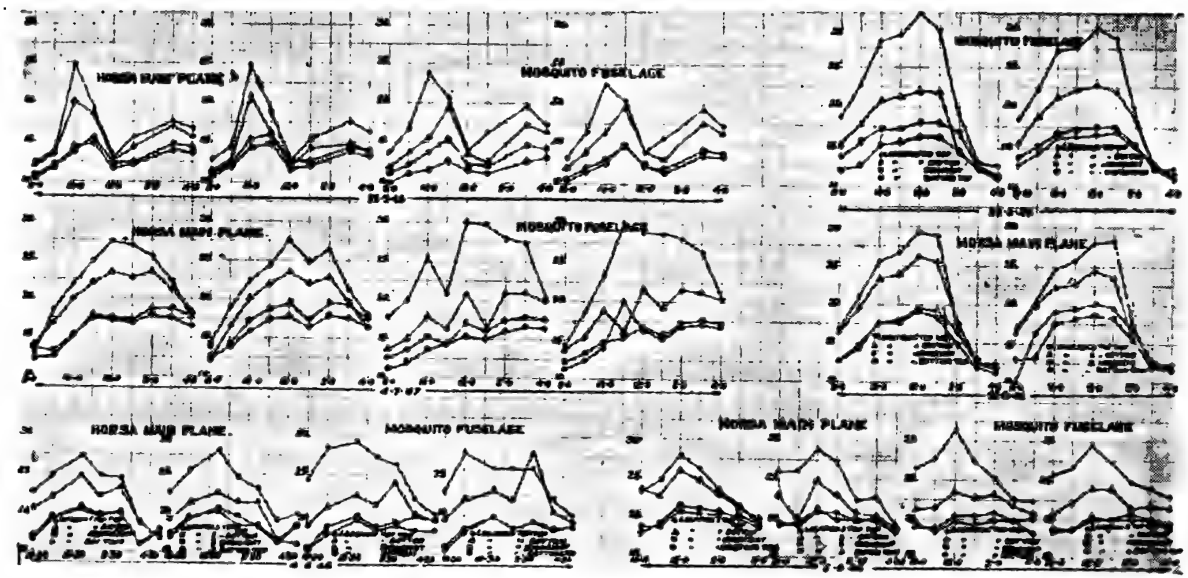

FIG. 7.—Temperature readings for Horsa mainplane and Mosquito fuselage.

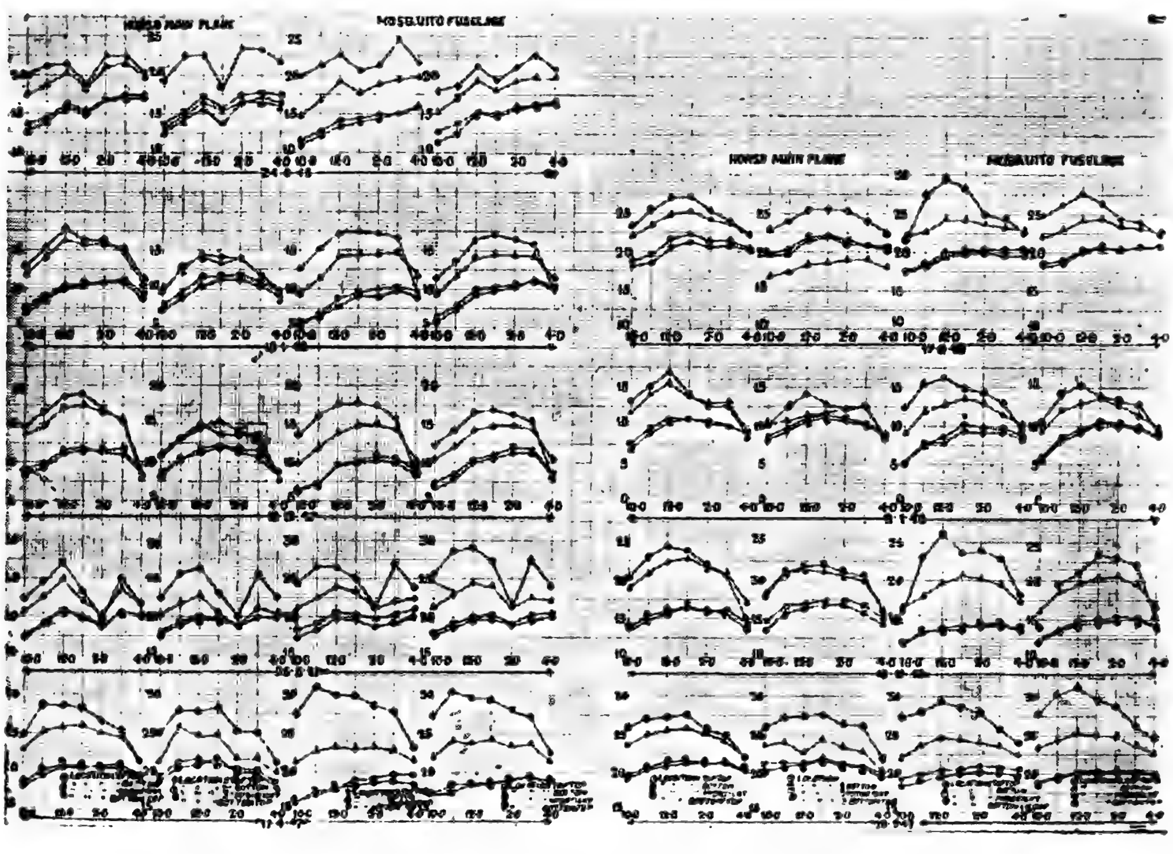

FIG. 8.—Temperature readings for Horsa mainplane and Mosquito fuselage.

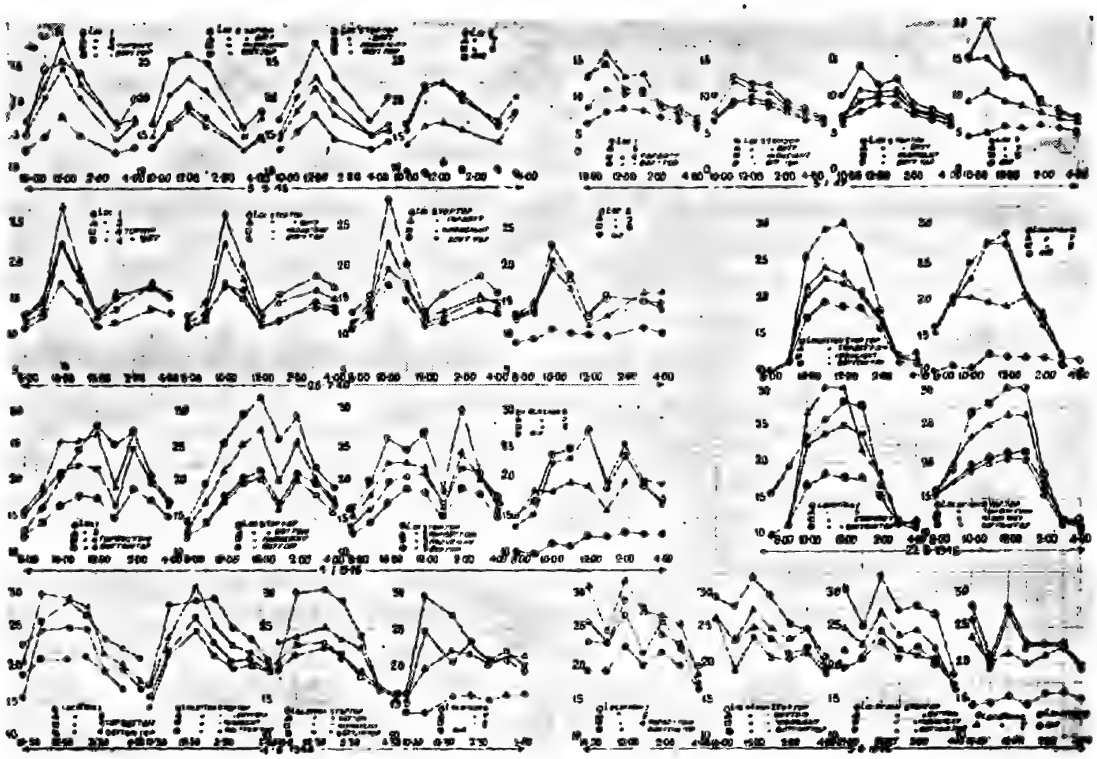

FIG. 9.—Temperature readings for Horsa tailplane.

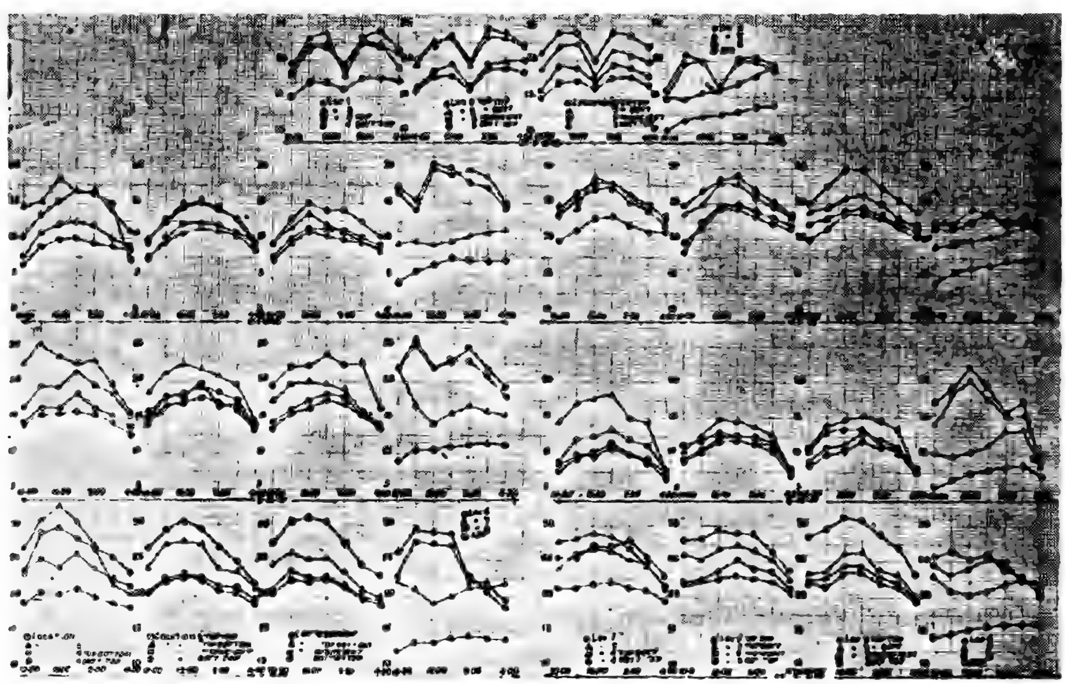

FIG. 10.—Temperature readings for Horsa tailplane.

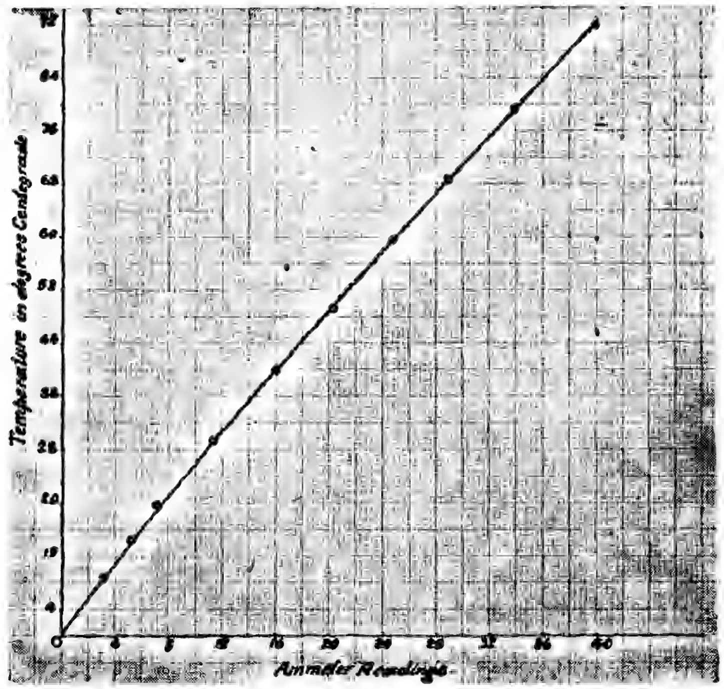

FIG. 11.—Thermocouple calibration curve.

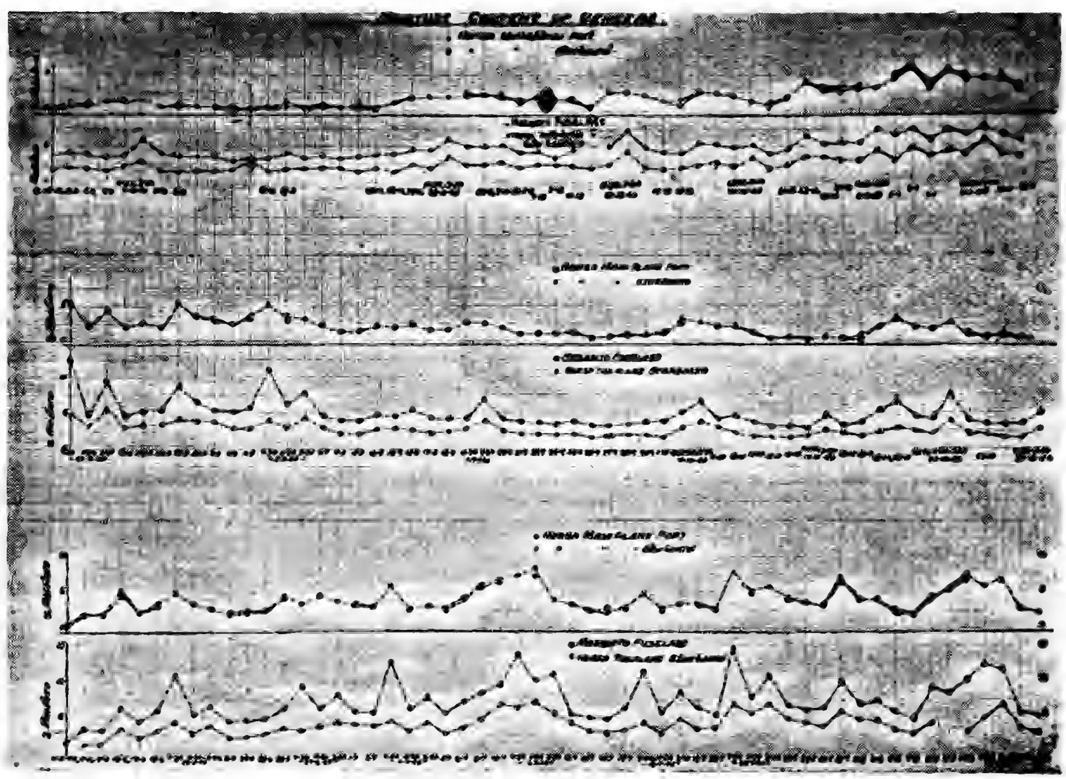

FIG. 12.—Moisture content of veneer.

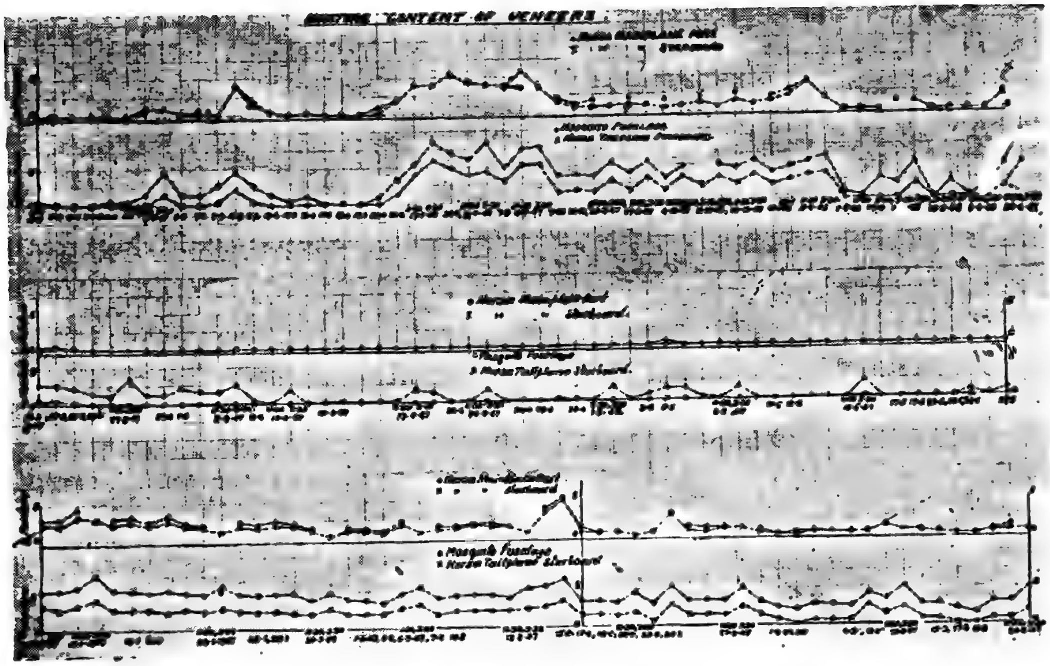

FIG. 13.—Moisture content of veneers.

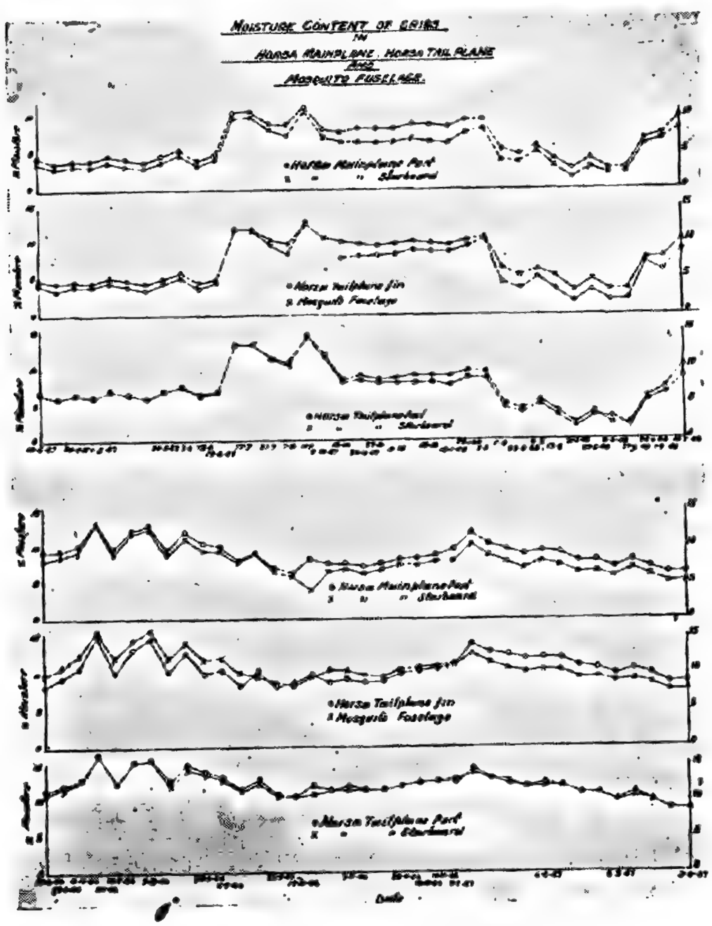

FIG. 14.—Moisture content of grids.

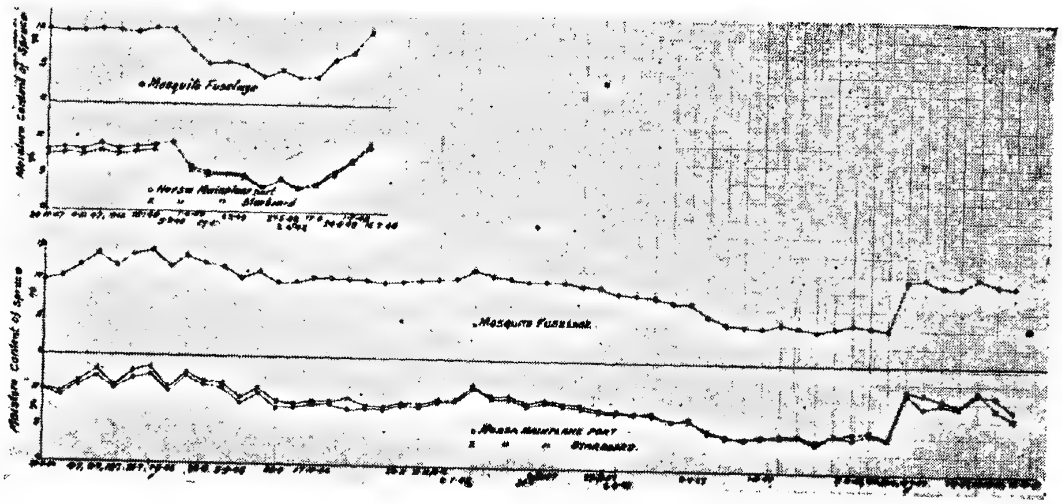

FIG. 15.—Moisture content of spruce.

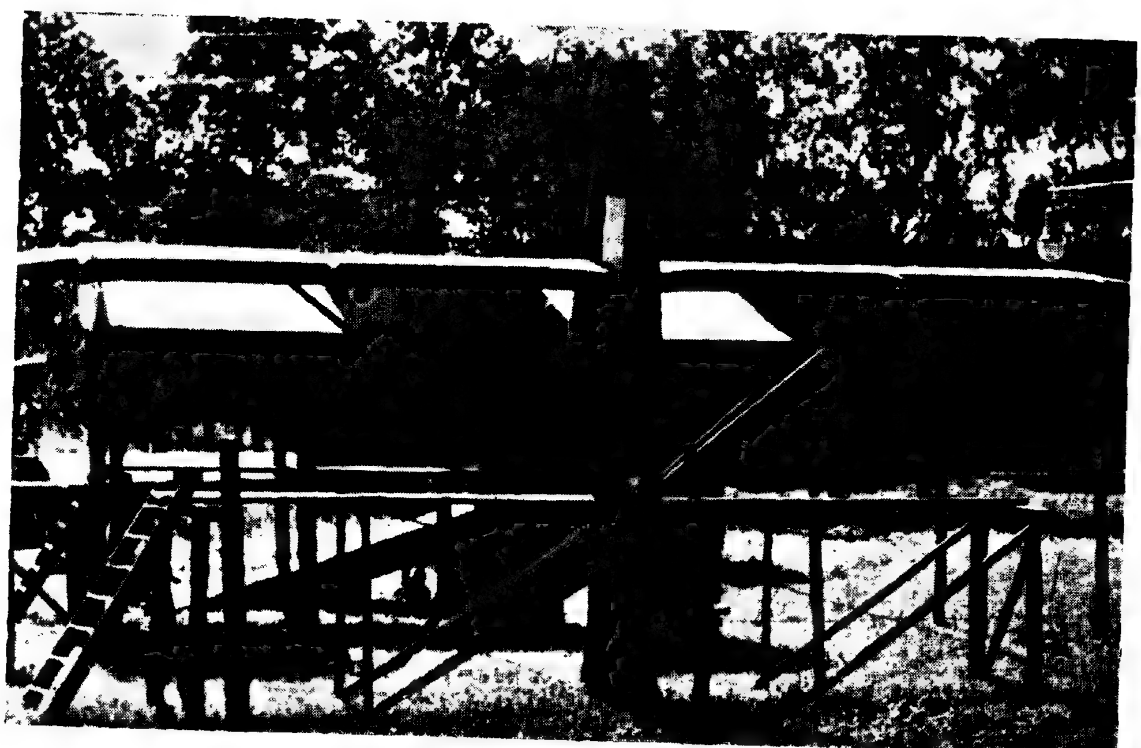

FIG. 16.—Condition of resin bonded Horsa tailplane at the end of the test.

TABLE I

Area under the temperature curves above 60°C.

Aircraft component	Location	Position	Area-units	
			22–8–46	17–4–47
Horsa mainplane ..	1	T.S.T. T.S. Mdht. B.S.	13·4 2·2 0 0	17·9 3·6 0 0
	2	T.S.	0	1·5
	3	T.S.T. Mdht. B.S.	9·4 0 0	14·8 0 0
Mosquito fuselage ..	1	T.S.T. T.S. Mdht. B.S.	25·9 0 0 0	34·7 0 0 0
	2	T.S.T. T.S. Mdht. B.S.	17·9 0 0 0	16·7 0 0 0
Horsa tailplane	1 5 4	T.S.T. T.S.T. T.S. B.S.	9·6 16·8 0·3 0	18·5 31·7 1·1 0
	2	T.S.T. T.S. Mdht. B.S.	20·0 4·8 0 0	26·3 10·6 0 0
	3	T.S.T. T.S. Mdht. B.S.	17·7 0 0 0	31·6 3·2 0 0
	6 7 8	.. .. ..	9·3 0 5·7	17·5 0 9·3
Air	..	..	0	0

T.S.T.—Top skin top.　　Mdht.—Mid-height.
T.S.—Top skin bottom.　　B.S.—Bottom skin top.

As can be seen from the table, top surface (top) location 1 of the Mosquito fuselage experiences the worst conditions. This is to be expected as due to the balsa core and the air gap insulation temperature is likely to be higher and remain higher for a long time. The lower surface of top skin in none of the locations in the Mosquito reaches 60°C. whereas in the mainplanes (paper I) even the bottom surface can attain 60°C. The Mosquito fuselage is subjected to less severe conditions in locations other than the top surface top. Next in order of severity is the top surface (top) in *several* locations in the Horsa tailplane and then in the Horsa mainplane. In the Horsa mainplane the top surface can also undergo these conditions. In the tailplane the mid-height can also attain *the same* conditions. Taking the components as a whole the severity of conditions in decreasing order of magnitude is as follows : Horsa tailplane, Horsa mainplane, Mosquito fuselage.

Maximum temperature gradients between the top surface and bottom varied from 23·6°C. in the Horsa mainplane (locations 1 and 3) on 5–7–46 to 37·1°C. in the Mosquito fuselage (location 1) on 3–8–46. Horsa tailplane was intermediate (vide, Table II).

TABLE II

Temperature Gradient in Aircraft Components

Component	Date	Location	Temperature °C.		
			Top	Bottom	Difference
1	2	3	4	5	6
Horsa mainplane ..	4–6–1946	3	67	50·4	16·6
		1	65·2	51·2	14·0
	5–6–1946	3	68·6	52·1	16·5
		1	67·0	53·0	14·0
	20–6–1946	3	67·2	45·8	21·4
		1	66·1	45·4	20·7
	4–7–1946	3	66·1	44·4	21·7
	5–7–1946	3	69·4	45·8	23·6
		1	70·4	46·8	23·6
	5–8–1946	3	67·8	44·9	22·9
	22–8–1946	1	69·4	47·6	21·8
	14–9–1946	1	68·6	47·6	21·0
	18–10–1946	1	65·6	44·9	20·7
	3–4–1947	1	67·0	47·6	19·4
	16–4–1947	1	69·4	51·6	17·8
	19–6–1947	3	68·0	52·0	16·0
Mosquito fuselage ..	4–6–1946	1	69·4	47·6	21·8
		2	62·8	46·8	16·0
	5–6–1946	1	74·6	46·8	27·8
		2	70·4	49·5	20·9
	8–6–1946	1	69·4	44·0	25·4
	13–7–1946	1	71·2	39·5	31·7
	18–7–1946	1	71·6	40·3	31·3
	3–8–1946	1	72·8	35·7	37·1
	22–8–1946	1	75·4	44·9	30·5
		2	71·6	42·2	29·4
	25–8–1946	1	74·6	43·2	31·4
	26–9–1946	1	73·6	40·3	33·3
	12–10–1946	1	72·0	37·2	34·8
	15–4–1947	1	76·2	44·4	31·8
	16–4–1947	1	77·4	44·0	33·4

(*contd.*)

TABLE II—(*concld.*)

Temperature Gradient in Aircraft Components

Component	Date	Location	Temperature °C.		
			Top	Bottom	Difference
1	2	3	4	5	6
Horsa tailplane ..	4–6–1946	3 2	72·0 68·6	54·8 64·0	17·2 4·6
	5–6–1946	3 2	75·4 75·2	56·6 65·2	18·8 10·0
	8–6–1946	3 2	70·8 63·6	50·4 52·1	20·4 11·5
	21–6–1946	3 2	73·6 74·0	46·8 54·0	26·8 20·0
	4–7–1946	2	75·0	53·1	21·9
	30–7–1946	3	77·0	46·8	30·2
	11–9–1946	2	71·2	53·0	18·2
	28–9–1946	3	68·6	49·0	19·6
	15–4–1947	3	73·6	53·4	20·2
	15–5–1947	3	75·0	57·4	17·6

Maximum temperatures in location 3 of the Horsa mainplane varied from 66·1°C. to 69·4°C. In location 1 they varied from 65·2°C. to 70·4°C. In the tailplane locations 2 and 3 experienced the severest conditions, and even the bottom attained temperatures of 65°C.

Moisture.—The results for the variation of moisture content of veneers, spruce specimens and grids in the aircraft components and air are shown in Figs. 12 to 15 and Tables III and IV.

TABLE III

Moisture content of veneers (Zanthoxylum rhetsa)

Aircraft component	Location	Date	Moisture Content				
			Maximum		Minimum		Difference % Moisture
			Time	% Moisture	Time	% Moisture	
Horsa mainplane	Port	11–7–1946 April '47 (All days)	11·30 ..	7·30 ..	.. 11·30	.. 0	.. .. 7·30
	Starboard	11–7–1946 April '47 (All days)	11·30 ..	8·50 ..	.. 11·30	.. 0	.. .. 8·50
Mosquito fuselage	..	25–7–1946 April '47 (All days)	7·30 ..	14·87 ..	.. 11·30	.. 0	.. 14·87
Horsa tailplane	Starboard	11–7–1946 April '47 (All days)	11–30 ..	7·24 ..	.. 11·30	.. 0	.. .. 7·24

TABLE IV

Moisture content of Grids and Spruce pieces

Aircraft component	Location	Date	MOISTURE CONTENT %					
			Maximum		Minimum		Difference	
			Grids	Spruce	Grids	Spruce	Grids	Spruce
Horsa mainplane	Port	11-7-1946	13·59	..	..	..	..	..
		20-5-1948	..	..	2·84	..	..	..
		1-8-1946	..	12·40	..	..	..	..
		3-6-1948	..	..	..	3·18	..	..
							10·75	9·22
	Starboard	11-7-1946	13·50	..	..	..	..	..
		20-5-1948	..	..	2·01	3·43	..	..
		1-8-1946	..	13·39	..	..	..	..
							11·49	9·96
Mosquito fuselage	..	1-8-1946	15·84	14·66	..	..	..	..
		20-5-1948	..	..	3·22	..	..	..
		3-6-1948	..	..	..	3·72	..	..
							12·62	10·94
Horsa tailplane	Port	11-7-1946	16·57	..	..	..	..	..
		20-5-1948	..	..	1·74	..	..	..
							14·83	..
	Starboard	11-7-1946	16·65	..	..	..	..	..
		20-5-1948	..	..	1·78	..	..	..
							14·87	..
	Fin	11-7-1946	15·16	..	..	..	..	..
		20-5-1948	..	..	1·78	..	..	..
							13·38	..

The highest moisture content for veneers recorded was 14·87% in the Mosquito fuselage and the minimum was nearly 0% in all the components. For the spruce pieces the highest value was again recorded in the Mosquito fuselage, 14·66%. Next in order was Horsa mainplane with 13·39%. If we consider the grids the highest value of over 16% (16·65 and 16·57) was attained in the Horsa tailplane in 2 locations followed by 15·84% in the Mosquito fuselage. The minimum moisture content for spruce specimens was about 3·18 to 3·72% and for grids 1·78% in the Horsa tailplane. The difference (grids) was largest in the Horsa tailplane (14·87) and least in the Horsa mainplane (10·75), closely followed by the Mosquito fuselage.

If we consider the number of weeks when moisture content of the grids was at various levels the Horsa tailplane seems to have had the worst conditions and the mainplane the mildest conditions.

FIG. 17.—Condition of casein bonded Horsa tailplane at the end of the test.

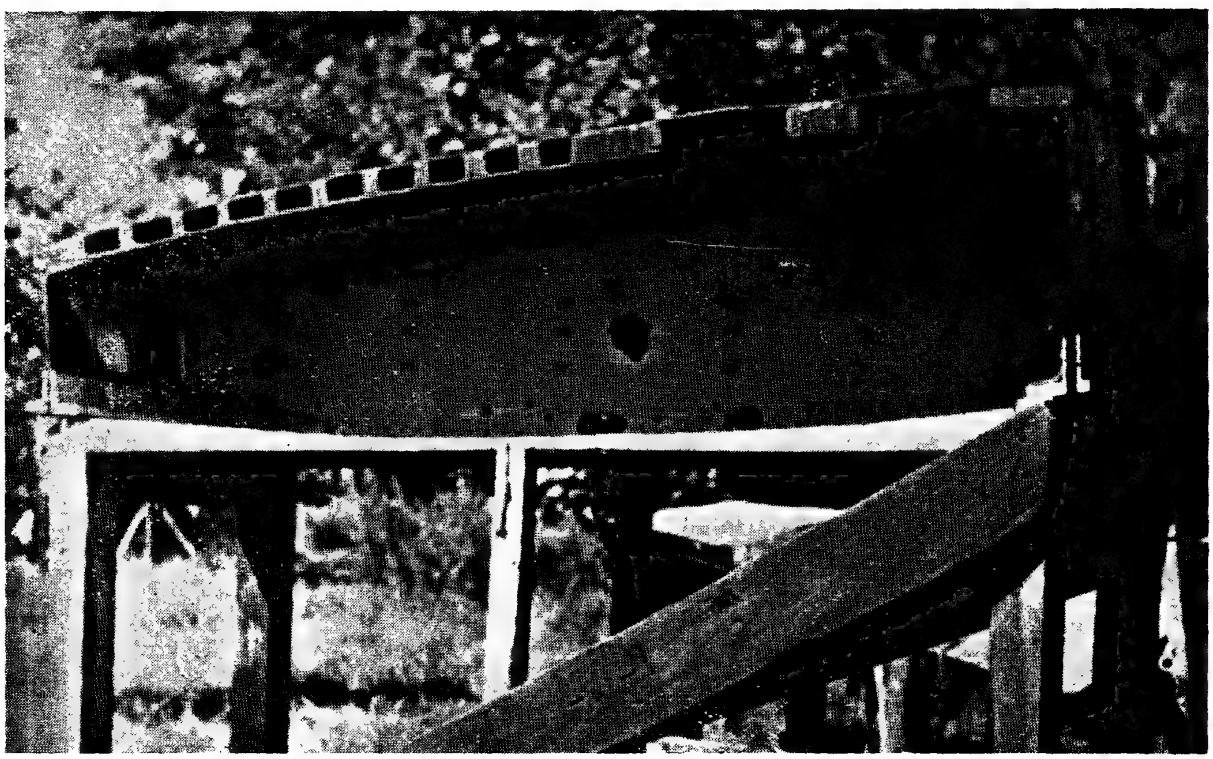

FIG. 18.—Section of Hornet wing at the end of the test.

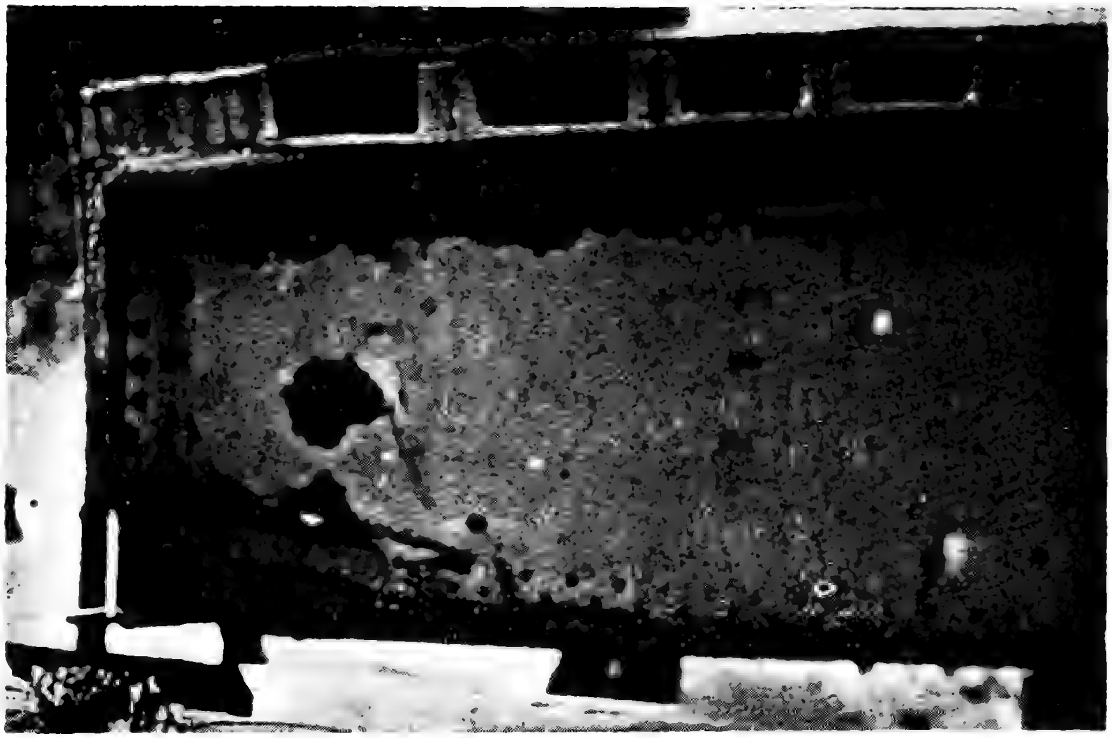

FIG. 19.—Section of Hornet wing at the end of the test.

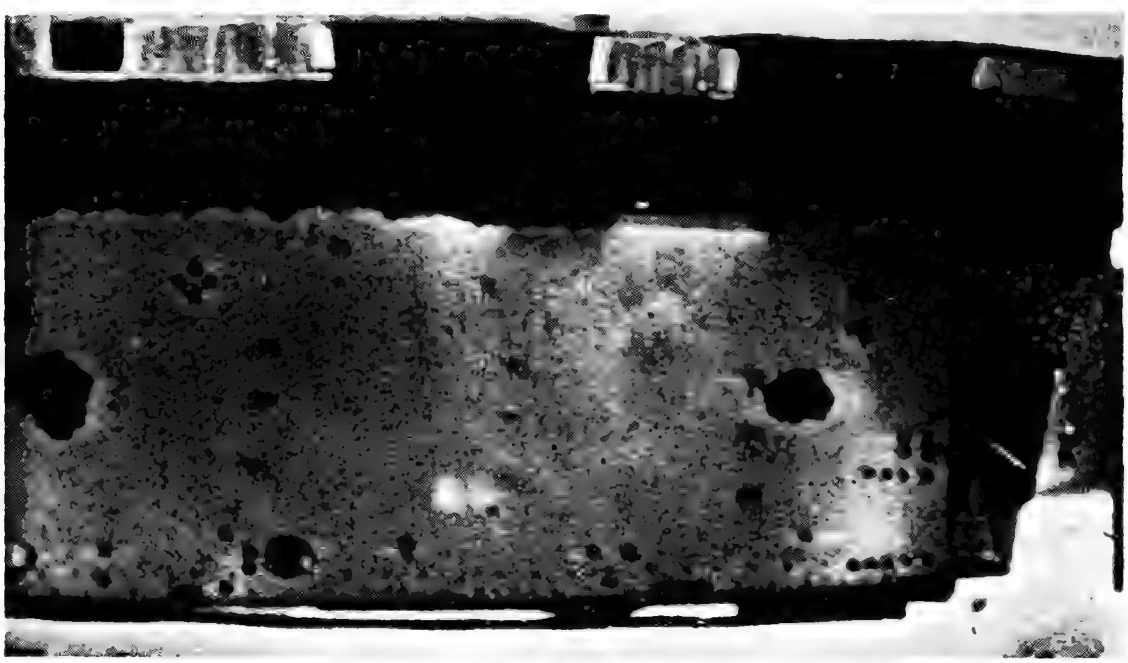

FIG. 20 Section of Hornet wing at the end of the test.

TABLE V

Number of weeks when moisture content of Grids and Spruce specimens was below 10%, 10–15% and above 15%

Aircraft component	Location	Period of observation weeks	Number of weeks when moisture content was					
			Below 10%		10–15%		Above 15%	
			Grids	Spruce	Grids	Spruce	Grids	Spruce
Horsa mainplane	Port	74	61	58	13	16	0	0
	Starboard	74	66	58	8	16	0	0
Mosquito fuselage	..	74	40	26	32	48	2	0
Horsa tailplane	Port	74	34	..	36	..	4	..
	Starboard	74	34	..	37	..	3	..
	Fin	73	50	..	22	..	1	..

Condition of the Components at the end of the test.—The condition of the components at the end of the trials can be seen from Figs. 2 to 4 and 16 to 20.

Mosquito fuselage section.—This had stood the weathering quite well (Figs. 3 and 4). At the end of 3 years there was only slight delamination at the ends of the balsa sandwich.

Horsa mainplane.—This has stood quite satisfactorily (Fig. 2).

Horsa tailplane.—This has done better than the casein bonded unit (Fig. 16). In the latter (Fig. 17), the fabric and wing tops had been completely destroyed. Bad deterioration of the wood in the fin had taken place. In the resin bonded tailplane deterioration of the fabric started later and the deterioration is less than in the casein bonded unit. Plywood in the wing tips is partly delaminated and fungal fruiting bodies are present. *Schizophyllum commune* is growing on the spar. Plywood glued to ribs easily come off the glue joint but there is no delamination in the plywood. Fungus was also found growing on the plywood.

Section of Hornet wing.—In view of the extreme severity of the conditions this may be said to have done satisfactorily (Figs. 18 to 20). There is some glue failure.

STRENGTH TESTS

At the end of the weathering tests the components (excepting the Mosquito fuselage and the section of Hornet wing) were broken down and the spruce and plywood tested for glue adhesion and strength.

Plywood.—In glue adhesion values of about 200 lb./sq. in. with complete wood failure were obtained. Results of tensile strength tests are given in Table VI and those of panel shear in Table VII. The highest tensile strength value recorded for the casein bonded unit is 11,801 lb./sq. in. while that for the resin bonded unit is 12,714 lb./sq. in. The corresponding minimum values are 2,590 lb./sq. in. and 7,703 lb./sq. in. As is to be expected the plywood at the bottom skin has higher strength than that from the top skin. If panel shear values are considered again in some locations values above 2,000 lb./sq. in. are noticed.

Spruce.—In most of the cases the spruce specimens tested pass the specification requirements as regards bending strength and several specimens also pass in the compression tests. Table VIII.

TABLE VI

Tensile strength tests on plywood taken from Horsa tailplanes at the end of the Weathering trials

Location		Tensile strength lb./sq. in.	
		Casein bonded	Resin bonded
Port ribs 12–14	Top	..	7704
,, ,, ,,	Bottom	11801	12714
,, ,, ,,	Spar T.E.	2066	10040
,, ,, 6–8	Top	6686	5378
,, ,, ,,	Bottom	11444	12530
,, ,, ,,	Spar T.E.	3988	7037
,, ,, 1–3	Top	4387	9565
,, ,, ,,	Bottom	10463	10494
,, ,, ,,	Spar T.E.	..	7250
Starboard ribs 1–3	Top	4777	8193
,, ,, ,,	Bottom	11040	10101
,, ,, ,,	Spar T.E.	6795	..
,, ,, 6–8	Top	3914	7586
,, ,, ,,	Bottom	9926	10231
,, ,, ,,	Spar T.E.	2590	8909
,, ,, 12–14	Top	Decayed	7565
,, ,, ,,	Bottom	,,	9440
,, ,, ,,	Spar T.E.	,,	7974
Fin Starboard side Centre		4769	9031
,, Port ,, ,,		9132	7938

T.E.—Trailing edge.

TABLE VII

Results of panel shear tests on plywood taken from Horsa tailplanes at the end of the Weathering trials

Location	Average thickness inches		Moisture %		Shear strength lb./sq. in.	
	a*	b†	a*	b†	a*	b†
Port ribs 4-6 Top ..	0·0528	0·1055	10·15	10·23	669	1377
,, ,, ,, Bottom ..	0·0642	0·1059	10·69	9·85	2410	1602
Starboard ribs 4-6 Top ..	0·0520	..	9·98	..	1133	..
,, ,, ,, Bottom ..	0·0669	0·0657	10·42	9·62	..	4579

a*—Casein bonded.
b†—Resin bonded.

TABLE VIII

Results of strength tests on spruce specimens taken from Horsa tailplanes at the end of the Weathering trials

Location	Moisture %		Specific gravity		Modulus of Rupture lb./sq. in.		Compressive strength lb./sq. in.	
	a*	b†	a*	b†	a*	b†	a*	b†
Rib 9 Port Top	11·52	11·33	0·3530	0·3665	9718	8812	4680	4960
,, 9 ,, Bottom	13·89	14·93	0·4262	0·3626	9285	8065	5507	3489
,, 10 ,, Top	13·69	12·58	0·3303	0·3456	7375	8388	4174	4309
,, ,, ,, Bottom	11·33	11·57	0·4390	0·3681	10173	8904	5152	4411
,, 9 Starboard Top	10·10	..	0·3533	..	9123	..	4515	..
,, ,, ,, Bottom	13·75	..	0·3203	..	6966	..	3439	..
,, 10 ,, Top	10·33	..	0·4435	..	11712	..	5730	..
,, ,, ,, Bottom	11·06	..	0·3636	..	10496	..	4611	..
Main Spar (Ribs 9 and 10) Port Top ..	10·89	12·67	0·3192	0·4065	7397	8488	3944	5306
,, ,, ,, ,, Bottom	14·36	11·74	0·3597	0·3677	7435	7832	4096	4858
,, ,, .. Starboard Top ..	11·81	11·62	0·4236	0·4368	9736	9346	5742	5786
,, ,, ,, ,, Bottom	14·88	14·13	0·3922	0·3414	9609	8149	5080	4274
Fin leading edge spar (Ribs 3 to 6) Starboard	11·36	11·69	0·4364	0·4603	9594	12874	5957	5676
,, ,, ,, ,, Port	11·99	12·73	0·3418	0·3519	9522	7440	4315	4335
,, trailing ,, ,, Starboard ..	12·97	13·66	0·3846	0·3835	8428	9580	4972	4772
,, ,, ,, ,, Port	8·86	13·69	0·3526	0·3766	8703	10519	4149	5177

a*—Casein bonded unit.
b†—Resin bonded unit.

NOTES ON THE UTILIZATION AND SILVICULTURE OF THE TIMBERS USED IN WOOD BASED INDUSTRIES OF INDIA

I. PLYWOOD INDUSTRY

1. GENERAL

From a modest start in Assam about two decades back, plywood making has become one of our key industries. The advantages that plywood possesses over solid wood are manifold. It gives lightness combined with increased strength : a normal plywood board being about 3 times as strong as a solid board of equal thickness. It eliminates knots and other similar defects. It may be had in large sizes which are quite unobtainable in solid wood. It effects great economy in the use of costly timbers, as only thin veneers, from them are used to top veneers from cheap wood used as backing. Further, plywood is very easy to work and can be bent to any shape. It is on account of these properties, that plywood is progressively ousting solid wood from a number of spheres, and is at the same time making the use of wood possible, for a variety of new purposes.

2. LOCATION OF THE INDUSTRY AND ANNUAL PRODUCTION AND CONSUMPTION OF PLYWOOD

The plywood industry is concentrated near Calcutta (which centre is mainly fed by the timber from Andamans) and along the Malabar Coast. In addition, Assam and Bombay have got a couple of large factories each and Uttar Pradesh, Travancore and Bangalore one each. The country's total annual production of plywood is estimated at 150 million square feet which is sufficient to meet the present total demand. About two-thirds of the total output is consumed by the tea-box industry, the remaining one-third being used for a variety of purposes in making furniture, cabinet and trunks, in the construction of bodies of motor vehicles, railway coaches and aeroplanes and houses.

3. ESTIMATE OF TIMBER REQUIRED BY THE INDUSTRY

The estimated annual consumption of timber for plywood at present is 75,00,000 c. ft. in the form of logs. As the demand for plywood is bound to rise with the progressive industrialization of India, it would be safe to plan for an annual production of 1,00,00,000 c. ft. of suitable timber, 50% of which may belong to species suitable for making tea-chest.

4. REQUIREMENTS OF TIMBER FOR THE SMALLEST ECONOMIC UNIT

The capacity of the existing plywood mills in the country varies over to wide range. Taking into account all factors, a factory producing 6 million sq. ft. of plywood annually, may be considered as the smallest economic unit. This will require 3,00,000 c. ft. of timber in the round.

5. CONSIDERATIONS FOR THE CHOICE OF RAW MATERIAL

Generally speaking the timber should be sound, free from resin, excessive knots and interlocked fibre. It should be available in the form of logs with a minimum mid girth of 4 feet and a minimum length of 6 feet. Green logs are preferred as they obviate the necessity of preliminary softening. Excessive taper, buttresses and other bulges may unduly reduce the conversion factor ; the logs should, therefore, be reasonably free from these defects. As plywood is utilized for a large variety of purposes further specifications will depend on the

particular purpose concerned. Whereas selected logs of the most costly furniture woods such as teak, *sissoo* and padauk may be required for top quality stuff, only the cheapest woods like *Lannea grandis*, *Bombax malabaricum* and *Spondias mangifera* can be utilized for low quality products.

6. TIMBERS SUITABLE FOR THE PURPOSE

The timbers found suitable for plywood are given below, the most commonly used ones being distinguished by an asterisk mark :—

(*A*) *Commercial Plywood*

CLASS I

Serial No.	Name of species	Distribution
1*	*Dalbergia latifolia* (Rosewood).	Sub-Himalayan tract from Oudh to Sikkim, Chota Nagpur, Central and Southern India.
2*	*Dalbergia sissoo* (*Sissoo*).	Sub-Himalayan tract from Indus to Assam up to 3-4 thousand feet. Cultivated in most parts of the country.
3*	*Tectona grandis* (Teak).	Indigenous in Central and Southern India in deciduous forests and cultivated as far north as Uttar Pradesh, Bengal and Assam.
4*	*Albizzia lebbek* (*Kokko*).	All over India from about 3,000 feet in the Himalaya downwards and in Andamans. Commonest in deciduous forests.
5	*Albizzia procera* (*Sufed siris*).	Sub-Himalayan tract from Yamuna eastwards, Bengal, Satpura range, Gujerat, South India and Andamans.
6*	*Amoora wallichii* (*Amoora*).	Sikkim, Assam, Burma and Andamans.
7*	*Palaquium ellipticum* (*Pali*).	Western Ghat forests from Kanara southwards.
8*	*Dysoxylum binectariferum* (White cedar).	Sikkim, Khasi hills, Chittagong and Western Ghats from Khandala southwards.
9*	*Dysoxylum hamiltonii* (White cedar).	Sikkim, Assam and Sylhet.
10*	*Dysoxylum malabaricum* (White cedar).	Evergreen forests of Western Ghats from north Kanara southwards.
11*	*Artocarpus hirsuta* (*Aini*).	Evergreen forests of Western Ghats from Konkan southwards up to 4,000 feet.
12	*Artocarpus integrifolia* (Jack).	Evergreen forests of Western Ghats from Konkan southwards up to 4,000 feet. Extensively cultivated for fruit throughout India.
13*	*Dipterocarpus indicus* (*Gurjan*).	Evergreen forests of Western Ghats from North Kanara southwards to Tranvancore up to 3,000 feet.
14*	*Dipterocarpus macrocarpus* (*Hollong*).	Upper Assam valley.
15*	*Terminalia myriocarpa* (*Hollock*).	Eastern Himalayas from Nepal to Assam up to 5,000 feet.
16*	*Michelia champaca* (*Champa*).	Nepal, Bengal, Assam and Western Ghats up to 3,000 feet.
17*	*Cedrela toona* (*Toon*).	Sub-Himalayan tract from Indus to Assam Chittagong, Burma, Western and Eastern Ghats and other hills of the Peninsula.
18*	*Calophyllum inophyllum* (*Poon*).	Eastern and Western Ghats and Andamans.
19*	*Calophyllum tomentosum* (*Poon*).	Western Ghats and Palni hills up to 5,000 feet.
20*	*Calophyllum spectabile*.	Chittagong and Andamans.
21*	*Calophyllum wightianum*.	Western Ghat evergreens from Konkan southwards.
22	*Shorea assamica* (*Makai*).	Assam.
23	*Juglans regia* (Walnut).	Himalayas from Afghanistan to Bhutan 4,500 to 11,000 feet.
24	*Polyalthia fragrans* (*Nedunar*).	Western Ghat evergreens.
25	*Phœbe goalparensis* (*Bonsum*).	Bengal and Assam hills.
26	*Carapa moluccensis* (*Pussur*).	Coastal forests of Bengal and Andamans.
27	*Chuckrassia tabularis* (*Chickrassy*).	Sikkim, Assam, Andamans, Western Ghats and Bengal.
28	*Betula alnoides* (Birch).	Himalayas from 5,000 to 10,000 feet from Sutlej eastwards, Khasi hills and Manipur.
29	*Acer oblongum* (Maple).	Himalayas up to 6,500 feet from Jhelum to Assam, Manipur.
30	*Acer cæsium* (Maple).	Western Himalayas chiefly at 7 to 10 thousand feet.
31	*Gmelina arborea* (*Gamari*).	Throughout India in deciduous and semi-evergreen forests.
32	*Adina cordifolia* (*Haldu*).	Throughout India in deciduous forests.
33	*Pterospermum acerifolium* (*Kanak champa*).	Sub-Himalayan region of Uttar Pradesh, Nepal, Bengal, Khasi hills, Manipur and North Kanara.

CLASS II

Serial No.	Name of species	Distribution
1*	*Canarium euphyllum* (White *dhup*).	Andamans mostly in deciduous forests.
2*	*Canarium strictum* (*Dhup*).	Evergreens of Western Ghats and Andamans.
3*	*Mangifera indica* (Mango).	Natural in Western Ghats, Satpuras, Assam and portion of the sub-Himalayan tract. Cultivated throughout India.
4*	*Vateria indica* (*Vellapiney*).	Western Ghats, North Kanara to Travancore up to 4,000 feet.
5*	*Machilus macrantha* (*Machilus*).	Western Ghats, North Kanara to Travancore up to 4,000 feet.
6*	*Lophopetalum wightianum* (*Narkeli*).	Western Ghats, evergreens from Konkan southwards.
7*	*Cullenia excelsa* (*Karani*).	Western Ghats from Coorg southwards up to 4,000 feet.
8*	*Holoptelia integrifolia* (*Kanju*).	Mixed deciduous forests of the sub-Himalayan tract from Chenab eastwards up to 2,000 feet, Central India, Chota Nagpur and Indian Peninsula.
9*	*Schima wallichii* (*Chilauni*).	Sub-Himalayan tract from Nepal eastwards up to 5,000 feet.
10	*Alnus nepalensis* (*Alder*).	Himalayas from Ravi eastwards—from 3,000 to 9,000 feet altitudes.
11	*Carallia integerima* (*Carallia*).	Tropical moist deciduous, semi-evergreen and evergreen forests throughout India.

CLASS III

Serial No.	Name of species	Distribution
1*	*Bombax malabaricum* (*Semal*).	Throughout India up to 3,500 feet, excepting the most arid parts.
2*	*Bombax insigne* (*Semal*).	Andamans and Western Ghats.
3*	*Boswellia serrata* (*Salai*).	Deciduous forests throughout India.
4*	*Lannea grandis* (*Jhingan*).	Deciduous forests throughout India.
5*	*Ailanthus excelsa* (*Gokul*).	Mixed deciduous forests of the Peninsula and sal forests of Central India.
6*	*Ailanthus grandis.*	Sikkim and Assam.
7*	*Ailanthus malabarica.*	Evergreen forests of Western Ghats.
8	*Garuga pinnata* (*Garuga*).	Widely distributed chiefly in deciduous forests.
9	*Trewia nudiflora* (*Gutel*).	Uttar Pradesh, Bengal Assam, Chota Nagpur and Western Ghats, chiefly in marshy places and along stream banks.
10	*Alstonia scholaris* (*Shaitan* wood).	Sub-Himalayan tract up to 3,000 feet from Yamuna eastwards and western Peninsula.
11	*Anthocephalus cadamba* (*Kadam*).	Nepal, Bengal, Assam, N. Circars and Western Ghats.
12	*Duabanga sonneratioides* (*Lamapati*).	Assam, Manipur, Andamans and Nicobars.
13	*Kydia calycina* (*Pula*).	Deciduous forests throughout India.
14	*Litsea polyantha* (*Litsea*).	Sub-Himalayan tract from Punjab to Assam, Satpura range, N. Circars.
15	*Spondias mangifera* (Hog plum).	Throughout India in deciduous forests.
16	*Sterculia alata* (*Sterculia*).	Evergreen forests of Tista valley, Sikkim, the Duars, Assam, Andamans and Western Ghats.
17*	*Sterculia campanulata.*	Deciduous forests of Andamans.
18*	*Sterculia villosa.*	Deciduous forests throughout India, Andamans and Burma.
19	*Tetrameles nudiflora* (*Maina*).	Tropical moist deciduous and evergreen forests in sub-Himalayan tract, Western Ghats and Nilgiris.

TEA-CHEST PLYWOOD

Serial No.	Name of species	Distribution
1*	*Schima wallichii* (*Chilauni*).	Sub-Himalayan tract from Nepal eastwards up to 5,000 feet.
2*	*Terminalia myriocarpa* (*Hollock*).	Eastern Himalayas from Nepal to Assam up to 5,000 feet.
3*	*Dipterocarpus macrocarpus* (*Hollong*).	Upper Assam valley.
4	*Dipterocarpus turbinatus* (*Gurjan*).	Cachar, Tipperah, Chittagong and Andamans.
5*	*Shorea assamica* (*Makai*).	Assam.
6*	*Palaquium ellipticum* (*Pali*).	Western Ghats from Kanara southwards.
7*	*Vateria indica* (*Vellapine*).	Western Ghats, North Kanara to Travancore up to 4,000 feet.

(*contd.*)

TEA-CHEST PLYWOOD—(*concld.*)

Serial No.	Name of species	Distribution
8*	*Bombax malabaricum* (*Semal*).	Throughout India up to 4,500 feet excepting the most arid parts.
9*	*Bombax insigne.*	Andamans and Western Ghats.
10*	*Artocarpus hirsuta* (*Aini*).	Evergreen forests of Western Ghats from Konkan southwards up to 4,000 feet.
11	*Terminalia procera* (*Badam*) (Syn. *Terminalia catappa*).	Andamans in littoral forests.
12	*Terminalia belerica* (*Bahera*).	Deciduous forests throughout India.
13	*Hymenodictyon excelsum.*	Dry deciduous mixed forests throughout India.
14	*Betula alnoides* (Birch).	Himalayas 5,000 to 10,000 feet from Sutlej to Assam.
15	*Phœbe goalparensis* (*Bonsum*).	Bengal and Assam hills.
16	*Michelia champaca* (*Champa*).	Nepal, Bengal Assam and Western Ghats up to 3,000 feet.
17	*Chukrassia tabularis* (*Chickrassy*).	Sikkim, Assam, Andamans, Western Ghats and Bengal.
18	*Trewia nudiflora* (*Gutel*).	Uttar Pradesh, Bengal, Assam, Chota Nagpur and Western Ghats.
19	*Adina cordifolia* (*Haldu*).	Deciduous forests throughout India.
20	*Anthocephalus cadamba* (*Kadam*).	Nepal, Bengal, Assam, N. Circars and Western Ghats.
21	*Sideroxylon longipetiolatum* (*Lambapati*).	Andamans.
22	*Tetrameles nudiflora* (*Maina*).	Tropical moist deciduous and evergreen forests in sub-Himalayan tract, outer-hills, Western Ghats and Nilgiris.
23	*Mangifera indica* (Mango).	Natural in Western Ghats, Satpuras, Assam and portion of sub-Himalayan tract. Cultivated throughout India.
24	*Zanthoxylum rhetsa* (*Mullilam*).	Western Ghats and Coast from Konkan southwards.
25	*Lophopetalum wightianum* (*Narkel*).	Western Ghat evergreens.
26	*Dalbergia sissoo* (*Sissoo*).	Sub-Himalayan tract from Oudh to Sikkim, Chota Nagpur, Central and Southern India.
27	*Tectona grandis* (Teak).	Indigenous to central and southern India in the deciduous forests : Cultivated as far north as Uttar Pradesh, Bengal and Assam.

7. NOTES ON SOME OF THE SUITABLE AND PROMISING SPECIES

(i) *Ailanthus excelsa*
(ii) *Ailanthus grandis*
(iii) *Ailanthus malabarica*
Please see para 6 of the note on the "Match Industry".

(iv) *Albizzia lebbek* (*Kokko*).—A large deciduous tree found all over India and Andamans in various types of forests ranging from dry deciduous to wet evergreen. Under forest conditions it often attains 6–10 feet girth with a long clear bole. It is usually scattered in the forest and is frequently planted along roads and near habitations. It is relished by elephants and other wild game and this probably may be the cause of its being not so common. It is a fast growing species. Exact statistics of growth are not available. The annual height and girth increments in the first 10 years on reasonably good sites may be 3 feet and 3 inches respectively.

Natural regeneration of *kokko* is often uncertain and sporadic. It can easily be raised by direct sowing *in situ*, or transplanting or through the use of root and shoot cuttings. Transplanting and stumping are best done with the break of the summer rains and stumps 0·3 to 0·5 inch in diameter, give best results. In Madras *kokko* has done well in poor dry areas and is, recommended for improving the economic value of such forests. Pure plantations are known to have suffered seriously from defoliator. Hence a mixture with suitable species is to be preferred.

(v) *Anthocephalus cadamba.*—Please see para 6 of the note on the "Match Industry".

(vi) *Artocarpus hirsuta* (*Aini*).—An important timber of the evergreen forests of the Western Ghats from Konkan southwards up to 4,000 feet. It is not common in the deciduous

forests and appears to have been driven out from there by fire. In suitable localities it grows well there too. It is stated to have been successfully raised in mixture with teak in Coorg. It requires a deep, rich, moist soil and is a strong shade bearer.

Natural regeneration is considered to be adequate in places. The seed, being edible, is destroyed in large quantities by monkeys. *Artocarpus hirsuta* is a good coppicer and reproduces by root suckers also. For artificial regeneration dibbling of fresh seed gives the best results. The seed takes 3–4 weeks to germinate. In Bengal it has been found to do well by stumping. In clear-felled areas it would probably be better to do the sowings under an artificially raised cover crop. Slash burning, after clear-felling, is considered to be helpful. But steps will have to be taken to protect the crop from being damaged by elephants.

Aini is a fast grower ; an average girth of 33½ inches is attained in about 10 years. This gives an annual growth increment of about 3 inches on the average.

(vii) *Adina cordifolia* .. Please see para 4 of the note on the "Bobbin Industry".

(viii) *Bombax insigne* ..
(ix) *Bombax malabaricum* } Please see para 6 of the note on the "Match Industry".

(x) *Boswellia serrata* .. Please see para 9 of the note on the "Paper Industry".

(xi) *Calophyllum* spp. (*Poon*) (*C. inophyllum* *C. spectabile*)
(*C. tomentosum* *C. wightianum*).

The *Poons* are essentially trees of the evergreen forests and have come into prominence only recently. The available information is summarized below :

C. inophyllum.—is a moderate sized ornamental evergreen tree with short thick and often crooked bole and is found along the east and west Coast of the Peninsula, Burma and Andamans. It is a littoral species going down to the edge of the sea and can be raised by direct sowings. Complete removal of the hard seed shell is reported to considerably hasten germination in Philippines.

C. spectabile.—occurs in the evergreen forests of Chittagong and Andamans.

C. tomentosum.—A very large evergreen tree of the Western Ghat evergreens up to 5,000 feet. It attains large sizes—150 feet height and 15 feet girth at B.H., with straight cylindrical bole, being fairly common. The species is a pronounced shade bearer and requires heavy shade in the early stages. Even heavy weedings are considered to be definitely harmful to young regeneration. Sowings are reported to do better than transplants. Stumps do not succeed.

C. wightianum.—found in the evergreen forests of the Western Coast from Konkan southwards.

(xii) *Canarium euphyllum*
(xiii) *C. strictum.* } Please see para 6 of the note on the "Match Industry".

(xiv) *Cedrela toona* (*Toon*).—A large deciduous tree occurring in the sub-Himalayan tract and valleys of outer Himalayas from Indus to Assam up to 4,000 feet in Chittagong, Burma, Chota Nagpur, Western and Eastern Ghats and other hills of the Peninsula. It generally frequents moist localities such as ravines, banks of streams and even swamps. It is frequently cultivated and if tended and watered in youth is capable of growing in comparatively dry climates and situations.

Toon is a moderate light demander. The young plants require protection against insolation in the first few years. It is frost-hardy but susceptible to damage by fire and drought.

It is very much liable to be attacked by the fruit and shoot borer, *Hypsipyla robusta*, in early stages. The plant, however, recovers completely in about the 6th to 8th year.

Natural regeneration in suitable localities is satisfactory though not adequate to meet the total requirements. It is best propagated artificially by planting stumps, 0·6 to 0·9 inch in diameter, during the beginning of the monsoon. The stumps can be stored for 10 to 12 days without appreciably reducing their vitality. *Toon* can also be regenerated by direct sowings and entire transplanting, though the results are much inferior to those obtained from stumps. The seed being light, is easily washed away by rain, both in the field and the nursery.

Toon is a fast growing species. Fifty trees measured in Assam gave an average height of 63 feet and average girth of 22 inches at the age of 22 years. In Saharanpur plantations the species had an average height of 21 feet and average girth of 11 inches at 6 years age. These figures, for 16 years age, in the same locality, were 34 feet and 32 inches respectively. Data collected from 10 measurements of 4 Sample Plots in Bengal indicate the following average rate of growth for that part of the country :

Age	Height	Diameter
years	*feet*	*inches*
5	37	4·7
10	54	7·2
15	66	9·1
20	74	10·5
25	79	11·8
30	81	13·0
35	82	14·2

On account of the variety of uses to which the wood is put to, the natural supplies of *toon* cannot be regarded as adequate. In addition to being a very popular general utility and furniture timber it is good for plywood and handles and inner ply of tennis and badminton racquets. Lamination and compregnation are opening out new fields for its use. Compregnated *toon* has been found suitable for shuttles (and dichromate padding machine bearings). With lamination it promises to do well for rifle half-wroughts and snow shoes.

(xv) *Cullenia excelsa*.—A moderate sized to large evergreen tree indigenous to the Western Ghats from Coorg southwards up to 4,000 feet. The species is a strong shade bearer and like *Calophyllum tomentosum* even heavy weedings are harmful in the seedlings stages. It is not a good coppicer.

(xvi) *Dysoxylum* spp. (White cedar.—(*D. binectariferum, D. hamiltonii* and *D. malabaricum*).

The *white cedars* are good quality timbers combining lightness with strength and possessing high working qualities. Like so many other species, they have come into prominence recently. The details about their distribution, silvicultural and regeneration problems have not so far been studied in detail. Available information is summarized below :—

D. binectariferum is found in the evergreens of Sikkim, Assam, Chittagong and Western Ghats. Natural regeneration is usually inadequate. Entire transplants from the nursery appear to have been successful in Burma.

D. hamiltonii.—Occurs in Assam and Sylhet.

D. malabaricum.—A large tree of the evergreen forests of the Western Ghats from Kanara southwards. Natural regeneration is believed to be inadequate. The species does not seed frequently and the little seed that is produced is mostly destroyed by rodents. The seed keeps well for 6 weeks in wet gunny bags. In clear-felled areas natural undergrowth is thought to be beneficial to the growth of regeneration.

(xvii) *Gmelina arborea.*—Please see para 4 of the note on the "Bobbin Industry".

(xviii) *Holoptelia integrifolia.*—Please see para 4 of the note on the "Bobbin Industry'.

(xix) *Hymenodictyon excelsum.*—Please see para 6 of the note on the "Pencil Industry".

(xx) *Kydia calycina.*—Please see para 6 of the note on the "Match Industry".

(xxi) *Lannea grandis.*—Please see para 9 of the note on the "Paper Industry".

(xxii) *Lophopetalum wightiana.*—Please see para 6 of the note on the "Pencil Industry".

(xxiii) *Machilus macrantha.*—Please see para 6 of the note on the "Match Industry".

(xxiv) *Mangifera indica* (Mango).—In the wild state, the mango occurs in the moist tropical forests of Burma, Andamans, Khasi hills, Assam, Sikkim and portions of the sub-Himalayan tract up to Kumaon-Garhwal, Chota Nagpur, the hills of the Satpura range and the Western Ghats. It is a moderate shade bearer and affects ravines and moist shady places. As it has been available in only small quantities from the forest, it has not been considered to be of much importance as a forest species. On account of the fine fruit, dense and cool shade available all the year round and timber which has been sought after for a variety of purposes, the mango, perhaps, has been the most popular of the cultivated trees in India. Excepting for the very dry parts, mango groves form an integral part of the typical Indian country-side. It is the cultivated mango which has been the major source of timber for the various industries.

For shade, timber and poor quality fruit, mango is best raised by direct sowing *in situ*. The technique of raising the cultivated varieties are well known and beyond the scope of forestry. They need not, therefore, be described. It is a fast growing species. Exact statistics of growth unfortunately are not available. In Burma, the average girth increment for forest grown mango, is about 1 inch per annum, indicating that the species should take about 65 years to attain a crop diameter of 24 inches. In avenues and orchards, it attains at least double this size during the same period.

Mango is one of our most useful trees. It is eminently suited for avenue and road-side planting. The timber is very much in demand for a large variety of purposes, including matches, plywood, packing cases, bobbins, carving and turnery work, planking, house construction and cheap furniture. Due probably to its association with gardening, the species has been totally neglected by the forest departments. It is high time that the prejudice disappeared. Besides raising it in roadside avenues and canal banks and in connection with the *Vana Mahotsava*, plantations of the species are worth raising.

(xxv) *Michelia champaca.*—Please see para 4 of the note on the "Aeroplane Timber".

(xxvi) *Palaquium ellipticum.*—(Syn : *Dichopsis elliptica*, Pali).—A tall tree of the Western Ghats from North Kanara southwards. It is a poor coppicer. Madras experience indicates, that for obtaining natural regeneration, removal of understory and weedings are necessary to get the seedlings on the site, and once unestablished regeneration is enough

quantities has been obtained, a drastic opening of the top canopy, amounting almost to clear-felling, helps it to shoot up into the saplings and pole stages. Direct sowings have given poor results. The species can, however, be propagated artificially by transplanting of nursery or forest seedlings. The root system being rather delicate careful handling of the seedlings is necessary. Basketted plants succeed best.

Palaquium seed can be stored in gunny bags for a period of 6 to 8 weeks. Germination is about 40%. Soaking in cold water for 24 hours is beneficial and improves germination by about 10%. Germination usually starts after about a month.

(xxvii) *Schima wallichii*.—A tall evergreen tree of the sub-Himalayan tract from Nepal eastwards ascending up to 5,000 feet, also found in Khasi hills and in Manipur. It often occurs more or less gregarious. In the Duars it is often associated with sal.

Schima regenerates naturally abundantly wherever the canopy has been opened up. It is also a good coppicer. Seed is available in February–March and is very light in weight. It does not keep and is best sown as early as possible. Nursery beds have to be shaded. Germination commences in 3 weeks time and is usually poor. Seedlings should be picked out when 2–3 inches high. The nursery stock is transplanted in early rains.

Schima is a fairly fast growing species. A six-year plantation at Mongpoo in Bengal gave an average girth of 1–2 feet. The tree usually attains a height of 80–100 feet, and a girth of 10 feet or more. It is a moderate shade bearer and as such is very well suited to under-planting crops of light demanding species or for growing in mixtures.

(xxviii) *Sterculia campanulata*.—Please see para 6 of the note on the "Match Industry".

(xxix) *Sterculia villosa*.—A large deciduous tree common in the deciduous forests throughout India, Andamans and Burma. It is a strong light demander. Natural regeneration is usually adequate in suitable localities. The seed ripens in April–May and germinates at the beginning of rains. *Sterculia villosa* has been raised artificially by line sowings and stump planting in the open. Transplanting also should be possible. Overhead shade is injurious. Stiff, water-logged or badly aerated soil often results in large scale casualties due to damping off.

The seedlings are reported to attain a height of 2–4 inches in the first year at Dehra Dun, growth after that being quite rapid. Measurements taken in the Saharanpur, Siwaliks for a period of 7 years, indicate a mean annual girth increment of 0·3 inch for the locality.

Sterculia wood is useful for matches and cheap plywood. Bark is used for rough cordage and the tree also yields a white edible gum.

(xxx) *Terminalia myriocarpa* (*Hollock*).—A large tree of the moist deciduous and tropical evergreen forest of the eastern Himalayas from Nepal eastwards up to Assam, ascending in valleys and depressions up to 5,000 feet. It prefers damp situations and does well on a variety of soils. It is one of the pioneer species in Assam appearing in gregarious patches on newly exposed ground. It is a strong light demander, the plant requiring full over head-light, right from the beginning.

For natural regeneration *hollock* requires a clean germinating bed. As the seed is light and the tree seeds profusely, the species is usually regenerated naturally by the seed—tree method keeping the trees at a distance of 50 to 100 feet in lines 4 to 5 hundred feet apart and running at right angles to the wind direction. Natural regeneration often has got to be aided, and for this purpose the surplus plants from congested patches are usually transplanted. *Hollock* can be regenerated artificially by direct sowings on clean ground such as is left after raising a taungya crop or by transplanting.

T. myriocarpa is a very fast growing species. By the end of the 1st, 2nd and 3rd years the average heights usually are 6 feet, 12 feet and 20 feet respectively. The data available from 11 Sample Plots in Assam and Bengal gives the following growth figures.

Age	Average height	Average diameter
5	40	2·8
10	58	5·2
15	70	7·2
20	78	8·7
25	83	9·7
30	87	10·4
35	91	10·8

(xxxi) *Trewia nudiflora*.—Please see para 6 of the note on the "Match Industry".

(xxxii) *Tetrameles nudiflora*.—Please see para 6 of the note on the "Packing Case Industry".

(xxxiii) *Vateria indica*.—Please see para 6 of the note on the "Match Industry".

II. MATCH INDUSTRY

1. LOCATION OF FACTORIES ; PRODUCTION AND CONSUMPTION OF MATCHES

The number of match factories in India is over two hundred. Most of these, however, are organized only on a cottage industry basis, purchasing their splints and boxes ready-made from others. The number of those manufacturing their own splints and boxes is about twenty. Eight of these are situated in the Madras zone—one at Madras, one at Mysore and the rest are concentrated along the Malabar coast. About half a dozen factories are working in the Uttar Pradesh ; the biggest of these being at Bareilly. Bengal has got two factories and Assam, Bombay, Bhopal, Madhya Pradesh and Kashmir one each. The country's annual production, which is sufficient to meet the demand, is about 30 million gross boxes of matches.

2. THE QUANTITY OF TIMBER USED AND THE IMPORTANCE OF THE INDUSTRY IN THE NATIONAL ECONOMY

The match industry consumes about 1,20,000 tons (60,00,000 c. ft.) of timber in the round. Apart from the royalty paid to the forest departments or other private owners, every ton of wood converted into matches brings Rs. 750 as excise duty to the national exchequer. In addition to furnishing employment to a large number of people, it saves the country valuable foreign exchange to the tune of nearly 15 crores of rupees. The importance of the match industry in our national economy is, therefore, obvious.

3. CONSIDERATIONS FOR THE CHOICE OF TIMBER

The essential factors in the selection of matchwoods are straightness of grain, good fissility, strength and toughness, combined with lightness, good white colour, freedom from knots, and easy and cheap availability. The timber should be available in the form of logs, preferably green, with length 7 feet and over, and minimum mid-girth of 33 inches, under bark.

4. TIMBERS CONSIDERED SUITABLE FOR THE PURPOSE AND THOSE COMMONLY USED BY THE INDUSTRY

India does not possess a really first class matchwood of the quality of European *aspen* (*Populus tremula*) or Japanese *Shina-no-ki* (*Tilia japonica*), in large enough quantities. A number of species have been tested and some of them are considered suitable for splints and boxes. The more important of these are listed below. Species suitable for splints and boxes are distinguished by letters 's' and 'b' respectively and those commonly used, have been given an additional asterisk mark.

Serial No.	Name of species		Distribution
1	*Sideroxylon longipetiolatum* (*Lambapati*).	s.b.	Andamans.
2*	*Bombax malabaricum* (*Semal*).	s.b.	Throughout India up to 3,000 feet excepting the most arid parts.
3*	*B. insigne* (*Semal*).	s.b.	Andamans and Western Ghats.
4*	*Canarium strictum* (*Dhup*).	s.b.	Evergreen forests of Western Ghats and Andamans.
5*	*C. euphyllum* (White *dhup*).	s.b.	Andamans, most common in the deciduous forests.
6	*Endospermum malaccense* (*Bukota*).	s.b.	Andamans evergreen.
7*	*Lophopetalum wightianum.*	s.b.	Western Ghats.
8*	*Machilus macrantha.*	s.b.	Western Ghats.
9*	*Vateria indica.*	s.b.	Western Ghats.
10*	*Ailanthus excelsa.*	s.	Mixed deciduous forests of the peninsula and sal forest of Central India.
11*	*A. grandis.*	s.	Sikkim and Assam.
12*	*A. malabarica.*	s.	Evergreen forests of the Western Ghats.
13*	*Anthocephalus cadamba* (*Kadam*).	s.	Nepal, Bengal, Assam, N. Circars and Western Ghats.
14*	*Evodia roxburghiana.*	s.	Western Ghats.
15*	*Stercullia campanulata* (*Papita*).	s.	Deciduous forests of the Andamans.
16	*S. villosa.*	s.	Deciduous forests throughout India, Andamans and Burma.
17	*S. alata.*	s.	Evergreen forests of the Tista valley, Sikkim, the Duars, Assam, Andamans and Western Ghats.
18*	*Trewia nudiflora* (*Gutel*).	s.	Uttar Pradesh, Bengal, Assam, Chota Nagpur and Western Ghats.
19*	*Kydia calycina* (*Pula*).	s.	Deciduous forests throughout India.
20	*Dysoxylum malabaricum* (White cedar).	s.b.	Western Ghats.
21	*Mangifera indica* (Mango).	s.b.	Cultivated throughout India. Natural in Western Ghats, Satpuras, Assam and portion of sub-Himalayan tract.
22	*Spondias mangifera* (Hog plum).	s.b.	Throughout India in deciduous forests.
23	*S. acuminata.*	s.b.	Konkan hills, North Kanara, Malabar.
24	*Elæocarpus tuberculatus.*	s.	Western Ghats.
25	*Hymenodictyon excelsum* (*Kuthan*).	s.	Throughout India in deciduous forests.
26	*Pinus excelsa* (Kail).	s.	Himalayas 5 to 10 thousand feet from Afghanistan to Bhutan.
27	*Abies pindrow* (Silver fir).	s.	Himalayas 7 to 11 thousand feet from Afghanistan to Nepal.
28	*Symplocos spicata.*	s.	Assam, Khasi hills, Western Ghats, Nilgiris and Shevaroy hills.
29	*Alstonia scholaris.*	s.	Sub-Himalayan tract up to 3,000 feet from Yamúna eastwards and Western Peninsula.
30	*Holigarna arnottiana.*	s.b.	Western Ghats.
31	*Stereospermum chelonoides.*	s.b.	Moist deciduous and semi-evergreen and evergreen forests throughout India.
32	*Cinnamomum zeylanicum.*	b.	Western Ghats.
33	*Dipterocarpus indicus.*	s.	Western Ghats.
34	*Excœcaria agallocha.*	s.b.	Tidal forests on both sides of the Peninsula, Sundarbans and Andamans.
35	*Lannea grandis* (*Jhingan*).	s.b.	Throughout India in the tropical deciduous forests.
36	*Macaranga roxburghii.*	s.	Western Ghats, Orissa and N. Circars.
37	*Hydnocarpus wightiana.*	s.	Western Peninsula from the south Konkan along the coastal ranges.
38	*Holoptelia integrifolia* (*Kanju*).	s.	Deciduous sub-Himalayan forests of Punjab, Himachal Pradesh, Uttar Pradesh, Madhya Bharat, Chota Nagpur and the Peninsula.
39	*Boswellia serrata* (*Salai*).	s.	Throughout India in tropical deciduous forests.
40*	*Salix alba* (Willow).	s.b.	Cultivated in Kashmir and NW. Himalayas.
41*	*S. fragilis* (Willow).	s.b.	Cultivated in Kashmir and NW. Himalayas.

5. TIMBER REQUIREMENTS FOR THE SMALLEST ECONOMIC UNIT

It is difficult to define the smallest economic unit in the case of match industry on account of the absence of more reliable figures. A factory producing 3 lacs gross match boxes per year and consuming 60,000 c. ft. of wood annually may be taken as a suitable unit for the purposes of planning the supply of raw material.

6. NOTES ON SOME OF THE SUITABLE AND PROMISING SPECIES

(i) *Ailanthus excelsa*.—According to Troup, *A. excelsa* is "Indigenous in the Indian Peninsula found in the mixed deciduous forests and in the Madhya Pradesh in the Sal forests also". It is commonly planted throughout India. It is very fast growing. Six-year old plants in Saharanpur taungya (about 50 inches annual rainfall) attained an average height of 35 feet and average girth of 33 inches. The tree is susceptible to wind damage.

Natural regeneration of *Ailanthus excelsa* is often inadequate. It is a good coppicer and produces root-suckers. Troup states that it is easy to raise from seed and cuttings. Latest experimental work done in Madras indicates that in localities with a West Coast type of climate it can be best reproduced by direct sowings or entire transplanting and stumps give about 50% success. Due to its persistent and large branches, the species should be planted close.

Ailanthus excelsa has been found suitable for chemical pulp. It yields second grade plywood and fair quality splints which, however, are not so good as those of *Semal*. The biggest defect with the wood is that it develops blue stain within 2–3 days of peeling which suggest treatment with chemicals or kiln drying.

(ii) *Ailanthus grandis*.—A tall tree of the lower hills (up to 4,000 feet) and plains found in Bengal, Sikkim and Assam. On good sites it often has a height of 120–150 feet and a small crown. It is a light demander and regenerates well in blanks and open places, where the seedlings can get light. It is easy to raise artificially by direct sowing, transplanting or stumping. The seed is ripe in February–March and in Bengal it is sown in May–June. It cannot be stored till next year. In the nursery the seed should be sown at 3×3 inches espacement and the beds shaded in the early period. Germinations start after a month and is usually complete within 4 months. The plants can be transplanted with balls of earth in July or in the ensuing cold weather. They are not ready for root shoot cuttings till the next year. Direct sowings in the field may be done in lines 6 feet apart in patches with 6×6 feet espacement.

Ailanthus grandis is a fairly fast growing species. At Sukna (average rainfall 149 inches) 7-year plants had an average height of 38 feet and average girth of 23 inches. Stump analysis of a tree at plains level in Jalpaiguri division give a girth of 6½ feet, height of 110 feet and a timber volume of 120 c. ft. in 38 years.

(iii) *Ailanthus malabarica*.—Found in the evergreen forests of the Western Ghats, where it reaches large sizes. The silviculture of *Ailanthus malabarica* does not appear to have been studied. It is claimed to have been successfully introduced on the Chamundi hills in Mysore by the method of "pre-monsoon tree stumping".

Ailanthus malabarica is a splendid splint wood and due to its clean cylindrical bole the wood gives much higher yields than *A. excelsa*. It can be used for boxes as well. The species is, therefore, worth trying in suitable localities.

(iv) *Anthocephalus cadamba* (*Kadam*).—A large deciduous tree of the sub-Himalayan tract ascending to 3,000 feet and attaining a height of 100 to 125 feet in favourable localities. It occurs in Bengal, Nepal, Assam, Chota Nagpur, Northern Circars and West Coast from

North Kanara to Travancore. It is also cultivated in many parts of the country. It is one of our very fast growing species, attaining, under favourable circumstances, a girth up to 5½ feet in 15 years or 7½ feet in 20 years.

Natural regeneration is usually profuse in old taungyas and abandoned cultivated areas. It can be easily regenerated artificially by transplanting.

The wood is also in demand for packing cases and plywood. The species can be profitably raised in plantations on short rotations of 12 to 15 years.

(v) *Bombax insigne* (*Semal*).—A large deciduous tree of Burma, Andamans, Chittagong, Assam and Western Ghats from North Kanara southwards. It is often gregarious and is essentially a tree of the wet tropical regions free from frost. It is a light demander and fairly fast grower. A height of 7 feet is often attained in the first year. In Burma it is estimated to reach a girth of 6 feet in about 100 years .

Bombax insigne can be easily propagated by direct sowing or transplanting. It is also used on a large scale for cheap plywood and tea-chests.

(vi) *Bombax malabaricum* (*Semal*).—A very large deciduous tree with a long clean straight bole. It occurs throughout the country, from 4,000 feet in the Himalayas down to the tropical wet evergreens of the Western Ghats excepting the most arid parts. It is one of the earliest colonizers on flat alluvial ground along the stream banks and in open savannah grasslands. Although it does best on deep alluvial and well drained soils it is not fastidious in its soil requirements and comes up readily on a variety of formations.

Bombax is a fast growing species. In Haldwani and Tarai-Bhabar Divisions of the Uttar Pradesh, it attains an average d.b.h. of 32 inches and an average height of 101 feet in 50 years. Under good growing conditions the rate of growth may be as follows :—

Age (years)	10	20	30	40	50	60	70
Diameter (inches) ..	15	22	27	31	35	38	40

Data from two sample plots in Uttar Pradesh suggest the following growth rate for the locality :—

Crop age	Crop height	Crop diameter
	feet	*inches*
5	16	4·1
10	30	6·9
15	44	9·6

Natural regeneration is usually satisfactory in open areas. So great is the demand for *semal* timber for a number of purposes now, that the natural supplies have already fallen short of the actual requirements. These should be augmented by artificial plantations without further loss of time.

Bombax can be regenerated with ease by direct sowings, entire transplants or root and shoot cuttings. Due to its fast growth, tending is needed during the first two seasons only. The plantations can be established in 3 to 5 years time and the mature crop obtained in 20 to 40 years in the moister regions for the match and plywood industries. Experience gained in some states suggests that it is not advisable to grow *Bombax* in pure plantations and that a mixture is more desirable.

(vii) *Boswellia serrata* (*Salai*).—Please see para 9 of the note on the "Paper Industry".

(viii) *Canarium euphyllum* (White *dhup*).—An important timber species of Andamans, commonly associated with *padauk* in the deciduous areas and also found to a certain extent in other parts including the evergreen forests. In its natural habitat it attains a girth of 10–14 feet and a height of 80 to 135 feet with a long, clean and cylindrical bole. It is fast growing, reaching 6 to 9 feet height in 12 months. With proper thinnings it attains a crop diameter of 4·2 inches and crop height of 33·7 feet in 6 years.

The seed being covered by a hard testa, is difficult to germinate. Seed buried in wet ground germinates in about one week after sowing. Slight scorching of seed is also reported to be beneficial. Direct sowings are considered to give better results than planting of entire transplants or root and shoot cuttings. Due to its fast and straight growing habit a 12×12 feet initial espacement may be adopted.

The species is a strong light demander right from the start : sowings are, therefore, best done *in the open*.

Canarium euphyllum is our second best match-wood. The annual yield at present is estimated at 15,000 tons. The wood is good for plywood and packing cases. It is, therefore, suitable for growing in large scale plantations.

(ix) *Canarium strictum* (*Dhup*, Black-dammar).—A large resinuous tree with long, cylindrical bole, found in the evergreen forests of the Western Ghats from Konkan southwards and Andamans, going up to 4,500 feet in the Ghats. It is fast growing : a height of 6 to 9 feet being reached in the first year.

Artificial regeneration is best obtained from direct sowings in the open, at the break of the monsoons. A close espacement is not necessary due to its fast and clean growing habit. The species has not so far been studied in detail. Being suitable for plywood and packing cases and match industry it will continue to find a ready market.

(x) *Dysoxylum malabaricum*.—Please see para 7 of the note on the "Plywood Industry".

(xi) *Evodia roxburghiana*.—A small tree found in the Western Ghats from Konkan southwards up to the Nilgiris and the Palinis. Like so many other soft woods it has come into prominence only recently, and has not been studied in detail so far.

Attempts to regenerate it in Madras indicate that *Evodia* is a pronounced shade bearer and cannot be raised in clear-felled areas. With over-head shade it is best raised by entire transplants and stumps. Branch cuttings succeed fairly well. The plant has a shallow root system and weedings by scraping or pulling out the weeds lead to heavy casualties. The seed does not keep and should be sown immediately after ripening.

(xii) *Holoptelia integrifolia*.—Please see para 4 of the note on the "Bobbins Industry".

(xiii) *Hymenodictyon excelsum*.—Please see para 6 of the note on the "Pencil Industry".

(xiv) *Kydia calycina* (*Pula*).—A moderate sized deciduous tree common throughout India and Burma, chiefly in the mixed deciduous and Sal forests. It is a decided light demander and fairly frost hardy species. The rate of growth is fast and the species reaches maturity at a comparatively early age. It is estimated to reach an average girth of 2 feet in 15 years' time under natural conditions. Under plantation conditions the growth rate is much faster. Six-year old tree in the Lachiwala *taungya* of Dehra Dun division (annual rainfall of 80 inches) had 18 inches girth and 30 feet height at 6 years age. In case of the

Saharanpur *taungyas* (50 inches rainfall) the everage girth and average height at the same age were 12 inches and 30 feet respectively.

Two sample plots in Uttar Pradesh have given the following figures for height and diameter growth :—

Crop age	Crop height	Crop diameter
5	30	3·8
10	35	4·8
15	40	5·7

Kydia is a good coppicer and sends out root-suckers. Natural regeneration is usually adequate. Artificial regeneration is best carried out in the open. Direct sowings, stumps and entire transplants put out both during the rains and winter have been found to be successful.

(xv) *Lannea grandis* (*Jhingan*).—Please see para 9 of the note on "Paper Industry".

(xvi) *Lophopetalum wightianum*.—Please see para 7 of the note on the "Plywood Industry".

(xvii) *Machilus macrantha*.—One of the little known trees of the Western Ghats ascending to 7,000 feet. It is a shade bearer and has been raised artificially at Karian Shola (Nilgiris) after clear-felling and burning under a cover crop of *Boga*. It is best regenerated artificially by putting out entire transplants or stumps under a top canopy, soon after the break of the monsoon.

(xviii) *Mangifera indica*.—Please see para 7 of the paper on the "Plywood Industry".

(xix) *Sideroxylon longipetiolatum* (*Lambapati*).—A tree of the Andamans evergreen forest, usually found on moist calcareous soils in almost pure patches. But such patches are rare. It is a shade bearer and can stand shade for a long time and then shoot up on being freed. It grows straight, tall and cylindrical with a long clean bole. Trees with girth 7 to 8 feet and height 100 to 125 feet are common.

Natural regeneration of *Sideroxylon* comes up plentifully during the course of regenerating the evergreen forest. Direct sowings and planting have also been successful.

Lambapati is very aptly called the "Ivory white wood" and is India's finest match-wood which probably comes up to the standard of the European *aspen* for match splints. It is also suitable for packing cases and plywood. It is worth trying in suitable localities in Assam, Bengal and Western Ghats.

(xx) *Sterculia campanulata* (*Papita*).—A common associate of ***Padauk*** and ***dhup*** in the deciduous forests of the Andamans. On favourable sites the tree attains height of 100 to 125 feet and girth of 10 to 12 feet with a long clean cylindrical bole.

Sterculia campanulata is a strong light demander. It is fast growing, reaching a height of 6–9 feet in the first year and 15–20 feet by the end of the 2nd year. The seed is light and does not stand exposure. It can be stored for 3 to 4 months. At Forest Research Institute the seed gave a 20% germination. Natural regeneration is usually regarded as adequate. The species is best regenerated artificially by direct sowings. As it is fast and straight growing, seed may be sown or dibbled in patches at 12×12 feet espacement.

Papita yields a creamy white wood, very good for match splints and packing cases. Annual yields from Andamans are estimated at 10 to 15 thousand tons of logs. Preliminary tests carried out in the Wood Technology Branch in February, 1948 indicate that the wood from trees grown in regeneration areas (as opposed to natural forest) are probably not suitable for match splints. This has not been confirmed so far.

(xxi) *Sterculia villosa.*—Please see para 7 of the note on the "Plywood Industry".

(xxii) *Trewia nudiflora* (*Gutel*).—A middle sized deciduous tree of the moist tropical forests, found particularly along the banks of streams and in moist swampy situations throughout the sub-Himalayan tract from Jamuna eastwards up to Assam and in Chota Nagpur and Indian Peninsula. The large fruit is buoyant in water, which habit is responsible for the dissemination of the species in riverain tracts. Natural regeneration is quite abundant near the mother trees. *Trewia* is easy to raise artificially from seed sown direct in lines, entire transplants or stumps. The seed collected late in season (October–November) stores better and can be used in April–May next year.

Trewia is a fast grower. In Uttar Pradesh the tree attains an average diameter of 24 inches in less than 50 years. In Buxa division at plains level a 44 years old tree was found to be 6 feet 10 inches in girth and 88 feet in height. Two sample plots in Uttar Pradesh have given the following average growth figures :—

Crop age	Crop height	Crop diameter
	feet	*inches*
5	30	3·5
10	42	5·7
15	50	7·5
20	56	8·7
25	59	9·5
30	61	10·0
35	63	10·3

(xxiii) *Vateria indica* (*Vellapiney*).—A large handsome evergreen tree of the evergreen Ghat forests occurring from North Kanara to Travancore ascending up to 4,000 feet, and occasionally found along rivers in the deciduous forests. It is often cultivated as an avenue tree in the Ghat districts of Mysore and in Malabar. It is one of the lesser known species which have come into prominence only recently. Its silviculture has not so far been much studied.

Natural regeneration of *Vateria* is said to be plentiful in the neighbourhood of older trees. The seedlings require certain amount of shade in the early stages. Seed keeps only for about a month. Trials so far made in Madras and Coorg suggest that natural regeneration is best obtained by direct sowings under a high canopy. Planting and stumping do not yield satisfactory results.

[*to be continued*]

THE EFFECT OF WATER-LEVEL ON THE RAINFALL OF A LOCALITY

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SUMMARY

Indications are forthcoming that it is possible to predict the rainfall of a locality from a study of the comparative minimum water-levels of a lake or reservoir in the summer before the break of the monsoons.

Originally it was intended to study the influence of forest-conservation in the catchment area over the annual rainfall of the locality. On a scrutiny of the data with this end in view, however, it became apparent that the minimum water-level of a lake, just before the break of the monsoon, influences somehow the annual rainfall of the locality. In this particular locality the rainfall is mostly confined in the months of July, August and September. This relationship has got its own significance, in as much as the rainfall of the locality may be predicted by a study of the minimum water-levels. There is an immense practical utility in such a prediction towards combating famine conditions, flood-control and grow more food campaign problems, etc.

The Jharia Water Board had constructed a dam in 1924 resulting in an artificial lake in Topchanchi area of Manbhum District. The remaining three sides are surrounded by hills covered with forests. The northern hills comprise the famous *Parasnath* hills—the highest point of Bihar. The artificial lake has got a storage capacity of 1164 million gallons with an overflow level at 72 feet. The water is ultimatley led to the Jharia Mines and the annual consumption of water of 1948–49 and 1949–50 were 867·2 and 947·2 million gallons respectively. A rain-gauge has been installed just in the centre of the catchment area and the data have been collected by the Jharia Water Board since 1927 which is reproduced below as supplied by them :—

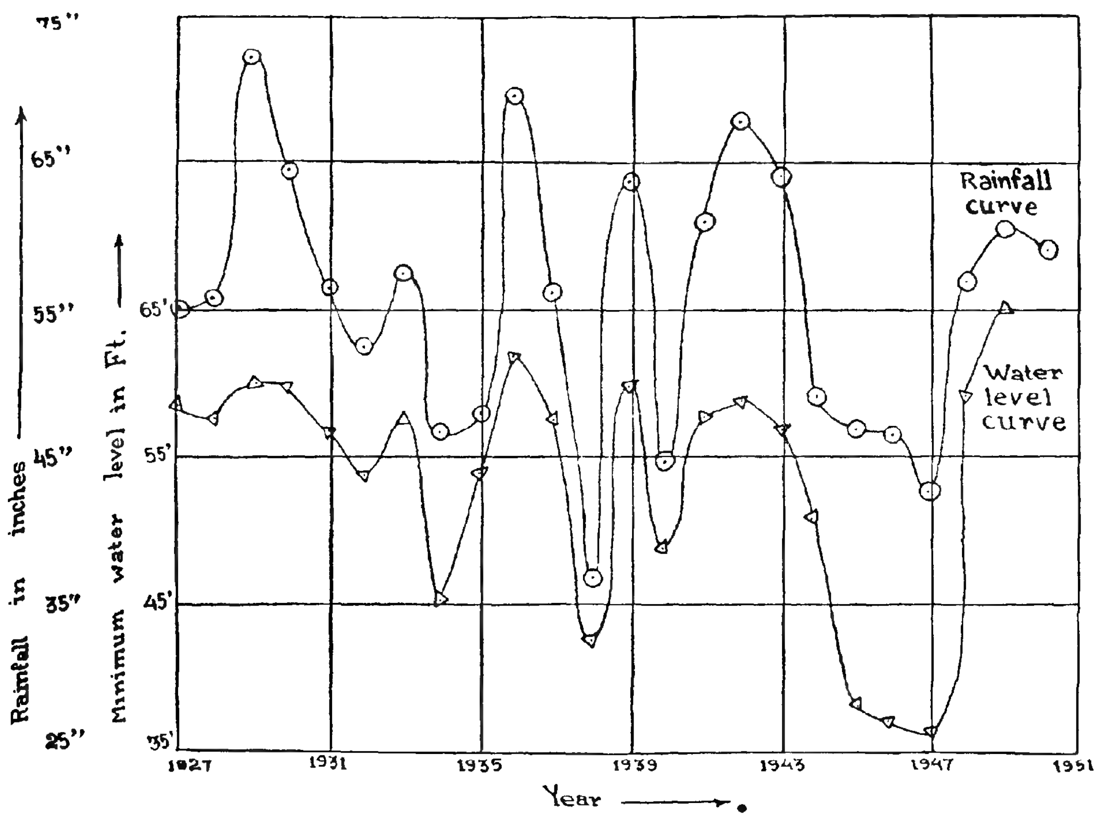
TABLE I

Date	Minimum lake level before rains			Rainfall during the year
	Level		Contents in million gallon	
	feet	*inches*		*inches*
6–6–28	58	7	583·73	54·89
7–7–29	57	5	544·00	55·93
24–6–30	60	$2\frac{1}{2}$	642·07	72·03
30–6–31	59	$9\frac{1}{2}$	626·75	64·24
5–7–32	56	5	511·29	56·24
23–6–33	53	$6\frac{1}{2}$	424·10	52·67
15–6–34	57	9	556·10	57·70
1–7–35	45	$4\frac{1}{2}$	226·65	46·51
21–6–36	53	$7\frac{1}{2}$	426·48	47·59

(*contd.*)

TABLE I—(*concld.*)

Date	Minimum lake level before rains			Rainfall during the year
	Level		Contents in million gallon	
	feet	*inches*		*inches*
31–7–37	61	11½	708·88	69·80
31–7–38	57	5	544·00	56·18
31–5–39	42	6	171·69	36·34
31–7–40	59	8	622·24	63·88
10–6–41	48	4	290·38	44·24
23–6–42	57	7	549·57	60·99
12–7–43	58	8½	588·06	67·85
25–6–44	56	9¼	522·69	64·06
24–6–45	50	9	348·72	49·00
20–6–46	37	11½	102·77	46·90
29–7–47	36	10	87·48	46·75
25–6–48	36	2½	79·55	42·19
29–6–49	59	3	607·22	56·90
10–6–50	65	4½	478·52	60·28



A graph has been plotted resulting in two curves depicting the variation of annual rainfall and the lowest water-level of the lake from year to year. The gradients of both the curves vary to the same degree in a particular year. To explain more clearly, if the lowest water-level curve ends in a peak for a particular year, the rainfall curve also shows a peak in that particular year. The same holds good with respect to minima and judging from this coincidence of the maxima and minima of both the curves from year to year it becomes apparent that the annual rainfall curve is a function of the lowest water-level curve and is directly related to it, as shown by the data of last 23 years.

From Table No. I it is also evident that the lowest water-level of the lake occurs either in June or July, i.e., just before the break of the monsoon. If the lowest water-level goes down unusually low, the corresponding rainfall in the ensuing rains is also unusually low while if the lowest water-level is well above the average in a year, the rainfall is also heavy in comparison with the average rainfall of past years. From this it would appear that at least with respect to this particular locality it is possible to predict the rainfall through a study of the lowest water-levels of the lake.

A reference (1) is invited in this direction to the experiments being conducted by Dr. Mahajan at Patiala on the evaporation of water and rainfall at Patiala from which it would appear that the rainfall during the rainy season can be predicted by comparing the evaporation of water in the months (April to June) preceding the rainy season in any year with that of several preceding years. Evaporation is one of the important factors influencing the water-level of a lake. However it would be interesting to collect field data from some more centres to corroborate these views and for investigating the various factors which can be taken into account for predicting the rainfall of other localities.

Thanks are due to the Conservator of Forests, Bihar for referring the writer to the Patiala experiments and to the Engineer, Jharia Water Board for sending in the mateorological data.

References

(1) Mahajan, L. D., 1951—Evaporation of water and rainfall at Patiala—Science and Culture, Vol. 17, No. 4, October, 1951.

INDIGENOUS CELLULOSIC RAW MATERIALS FOR THE PRODUCTION OF PULP, PAPER AND BOARD

PART X.—WRITING AND PRINTING PAPERS FROM *PANNI* GRASS (*VETIVERIA ZIZANIOIDES*)

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SUMMARY

Laboratory experiments on the chemical pulping of *panni* grass (*Vetiveria zizanioides*) by the soda process are described. Pilot plant experiments on the production of chemical pulps and writing and printing papers are also included. A sample of writing paper made from a mixture of 60% of *panni* grass pulp and 40% *sabai* grass pulp is appended. These experiments have shown that *panni* grass can be used for making chemical pulp and that writing and printing papers can be made from a furnish containing a mixture of *panni* grass pulp and a long-fibred pulp such as sabai grass pulp.

INTRODUCTION

Panni grass (*Vetiveria zizanioides*, Stapf.) is a densely tufted perennial grass from a branching root stock. Its roots are spongy and aromatic. The culms are stout and up to 5 feet tall and are smooth and glabrous, covered with sheaths which are strongly compressed, especially the lower. The leaves are 1–3 feet long, erect, rigid, firm or somewhat spongy, usually glabrous but sometimes hairy on the upper surface towards the base ; the margins are rough. This species is common on heavy soils in the open where it is often gregarious in thick tufts[1]. This grass is distributed throughout India ascending to an altitude of 4,000 feet. It also grows in Burma. In India, it is found in Punjab, Uttar Pradesh, Bengal, Madhya Pradesh, Bombay and Madras. It flowers between July and January. The estimated average annual yield of the dry grass is 2·4 tons per acre[2]. The fragrant roots of this grass are used for preparing an aromatic and medicinal oil. The well-known *khas khas* mats and hand fans are made from these roots.

According to the information supplied by the Divisional Forest Officer, Karnal, Punjab (India), this grass may cost about Rs. 21–34 per ton including the cutting and collection charges and royalty. At present, *panni* grass has no special use and is burnt down every year. At the instance of the Divisional Forest Officer, Karnal, Punjab (India), an investigation was undertaken in this Institute on the production of writing and printing papers from this grass. The results are recorded in this bulletin.

THE RAW MATERIAL

The *panni* grass (3 tons) for these experiments was supplied by the Divisional Forest Officer, Karnal. The supplies consisted of a mixture of *panni* grass and *dab* grass (*Desmostachya bipinnata*). The latter grass was present to the extent of about 30% of the whole consignment. The culms of the *panni* grass were 3·5–5 feet long. This grass was separated from the *dab* grass, crushed between the rollers of the factory crusher, cut into pieces of about 1 inch length on the grass chopper, and used for the digestions after sieving on the factory sieves to remove the fines.

PROXIMATE ANALYSIS

The *panni* grass was converted into dust and the portion passing through 60-mesh and retained on 80-mesh was used for the proximate analysis. The results are recorded in Table I.

TABLE I

Proximate analysis of panni grass

		% on the oven-dry basis except mositure
1.	Moisture	7·05
2.	Ash	5·75
3.	Cold water solubility	5·30
4.	Hot water solubility	10·18
5.	1% NaOH solubility	36·81
6.	10% KOH solubility	58·78
7.	Ether solubility	4·63
8.	Alcohol-benzene solubility	7·86
9.	Pentosans	25·45
10.	Lignin	25·80
11.	Cellulose (Cross and Bevan)	45·83

These results show that this grass contains a high percentage of hemicelluloses and consequently the cellulose content is low compared with other grasses such as sabai (*Eulaliopsis binata*) or *ulla* (*Themeda arundinacea*, Ridley) grass.

FIBRE DIMENSIONS

The measurements of the length and diameter of the fibres of the chemical pulp prepared from this grass were carried out by the usual methods followed in this laboratory. The average fibre length was found to be 1·20 mm., the maximum and minimum values being 3·53 and 0·42 mm. respectively. The fibre diameter varied from 0·0035 to 0·0280 mm. with an average of 0·0086 mm. The ratio of the average fibre length to diameter was 140 : 1.

PRODUCTION OF PULP

The crushed and chopped material was digested by the soda process in the laboratory digesters. A fixed material—liquor ratio of 1 : 5 was used in all the digestions. After the digestion was completed, the pulp was washed on a 60-mesh sieve. For the bleaching of the pulp, a solution of the bleaching powder was used in two stages. In the first stage, the pulp was bleached in 5% consistency at 35°C. using about 75% of the total requirement of the bleaching powder. The pulp was washed and treated in 5% consistency for 1 hour with 2% of caustic soda (on the basis of the air-dry pulp) at 70°C. The material was washed and bleached at room temperature in 5% consistency with the remainder of the bleaching powder solution. As the difference between the yields of the unbleached and bleached pulps was very high, the intermediate stage of alkali extraction was omitted in one experiment to find out whether this treatment was responsible for the low yields of the bleached pulp. The brightness of standard pulp sheets made from these two kinds of pulps was measured by means of the Photoelectric Reflection Meter Model 610 (Photovolt Corporation, U.S.A.). The results

are given in Serial Nos. 9*a* and 9*b*, Table II, in the last column ; these are expressed on the basis of the brightness of magnesium oxide equal to 100. The conditions of the digestions, the yields of the unbleached and bleached pulps, and the strength properties of the standard sheets made from these pulps are recorded in Table II.

PILOT PLANT TRIALS

In order to confirm the laboratory results, digestions were carried out on the crushed and chopped grass on the pilot plant of this Institute. About 650 lb. of the grass were used for each digestion. Three digestions were carried out. When the crushed and chopped grass was digested by the soda process with 15% of caustic soda in a concentration of 30 g./litre at 142°C. for 3 hours, the pulp was found to contain shives. In the next two digestions, the material was cooked with 17·5% of caustic soda in a concentration of 35 g./litre for 5 hours at 162°C. for the first 1 hour and 153°C. for the remaining period. Well-cooked pulps were obtained. Only the pulps from these two digestions were further processed. After the digestion was completed, the pulp was washed and bleached in the potcher. The bleaching was carried out in two stages with a solution of the bleaching powder without the intermediate alkali treatment. The yields of the unbleached and bleached pulps were 38·6 and 34·9% respectively. The bleach consumption was 5·8% of standard bleaching powder and the consumption of caustic soda in digestion was 13·5%. All these quantities are expressed on the basis of the air-dry raw material. After the pulp was beaten to the required freeness, rosin size, alum and China clay were added in the requisite quantities and writing paper was made on the Fourdrinier machine which was run at its maximum speed of 50 feet per minute. In one trial, 75% of the *panni* grass pulp was mixed with 25% of sabai grass pulp, and in the other run, 60% *panni* grass pulp was mixed with 40% of sabai grass pulp in the furnish. A sample of the latter paper is inserted in this bulletin. The strength properties of these papers are given in Table III.

DISCUSSION

The results of the laboratory experiments recorded in Table II show that the bleach consumption of the pulps from *panni* grass is high. Laboratory experiments carried out in this Branch have shown that chemical pulp of satisfactory whiteness can be obtained from sabai grass with a bleach consumption of 3–3·5% (on the basis of the air-dry grass).

The yield of unbleached pulps was quite high but the yield of bleached pulps was low when the intermediate treatment with caustic soda was used between the two stages of bleaching. This was supposed to be due to the removal of hemicelluloses by the alkali. Hence, an experiment was carried out in which this alkali treatment was omitted. The results of Serial Nos. 9*a* and 9*b* show that a higher yield of bleached pulp is obtained when this alkali treatment is omitted. The difference in the brightness of the pulp sheets from these two pulps is not much compared to the higher yield obtainable without this treatment. Similar experiments carried out in this laboratory on other grasses have also shown that a higher yield of bleached pulp but with a slightly lower brightness is obtained when this intermediate alkali treatment is omitted in the bleaching process. Hence, this treatment was not used in the pilot plant trials.

Under the conditions studied on the laboratory scale, the digestion conditions recorded in Serial Nos. 2, 8 and 9 are satisfactory for getting well-cooked pulps in good yields and with satisfactory strength properties.

On a pilot plant scale paper was made from a mixture of the pulps from *panni* and sabai grass for two reasons. Firstly, the pulp from *panni* grass is short-fibred. Secondly, this grass is not available in any one locality in sufficiently large quantities to feed an economic paper-making unit. Hence, this grass can be used with advantage for making chemical pulp

WRITING PAPER

made from a mixture of 60% *panni* grass pulp and 40% sabai grass pulp.

which can be mixed with sabai grass pulp in the manufacture of paper. The economic utilization of *panni* grass depends upon its availability in pure form free from other grasses such as *dab* grass.

Preliminary experiments showed that higher yields of pulps free from shives could be obtained by crushing the culms of *panni* grass before chopping. Hence the grass was crushed in all the subsequent experiments.

CONCLUSIONS

1. By employing suitable conditions for digestion, chemical pulp of satisfactory whiteness and strength properties can be prepared from *panni* grass. Bleach consumption is high compared to sabai grass pulp.

2. Since *panni* grass is not available in sufficiently large quantities in any one compact area to feed an economic paper-making unit and since the pulp is short-fibred, the best way of using the *panni* pulp for making writing and printing papers is to mix it with long-fibred pulp such as sabai grass pulp.

3. The economic utilization of *panni* grass for the manufacture of writing and printing papers depends upon its availability in pure form free from other grasses such as *dab* grass.

Thanks are given to the Divisional Forest Officer, Karnal, for the supply of *panni* and sabai grass free of cost for this investigation and for the supply of information regarding *panni* grass.

REFERENCES

1. Bor, *Indian Forest Records* (Botany), 1941, Vol. II, No. 1, 216.
2. Raitt and Hole, *Indian Forest Records*, 1913, Vol. V, Part III, 17.

TABLE II.—*Soda digestions of Veteveria zizanioides*

DIGESTION CONDITIONS AND PULP YIELDS

1	2	3	4	5	6	7	8	9
Serial No.	Total alkali as NaOH*	Concentration of alkali as NaOH	Digestion temperature	Digestion period	Alkali consumption as NaOH*	Unbleached pulp yield*	Bleach consumption as standard bleaching powder containing 35% available chlorine*	Bleached pulp yield*
	%	g./litre	°C.	hours	%	%	%	%
1	15	30	153	5	12·0	43·7	9·1	24·8
2	16	32	153	5	11·3	43·6	7·8	31·0
3	16	32	162	4	13·0	43·1	8·1	27·3
4	17	34	142 for the first 3 hours and 162 for the remaining period	5	11·7	43·6	8·0	25·2
5	17	34	153	5	12·2	43·6	7·6	24·3
6	17	34	162	3	14·2	44·4	8·1	28·9
7	17	34	162	4	12·0	40·6	6·5	26·7
8	17·5	35	162 for the first 1 hour and 153 for the remaining period	5	14·0	48·2	8·0	29·0
9*a*	17·5	35	162 for the first 2 hours and 153 for the remaining period	5	13·4	46·6	7·0	35·3
9*b*	,,	,,	,,	,,	,,	,,	,,	30·4

* The % is expressed on the basis of the raw material (air-dry).

and strength properties of standard sheets

STRENGTH PROPERTIES OF STANDARD SHEETS CONDITIONED AT 65% R.H. AND 68°F.

10	11	12	13	14	15	16	17
Freeness of pulp	Basis weight	Breaking length	Stretch	Tear factor (Marx-Elmen-dorf)	Burst factor (Ashcroft)	Folding resistance (Schopper)	REMARKS
c.c. (C.S.F.)	g./sq. metre	metres	%			double folds	
305	63·0	8570	3·9	68·2	44·5	480	Shives were present.
185	63·0	9470	4·0	68·3	50·6	370	Well-cooked pulp.
250	62·7	9040	3·5	70·1	46·8	360	Well-cooked pulp.
195	58·0	9180	4·4	68·9	41·4	510	Well-cooked pulp.
200	63·0	9790	4·5	70·6	47·0	300	Well-cooked pulp.
230	62·7	6170	2·0	70·1	46·8	310	Shives were present.
230	57·4	8440	3·9	63·5	40·4	330	Well-cooked pulp.
174	57·8	8620	3·7	63·5	46·0	510	Well-cooked pulp.
253	62·4	10070	3·8	65·7	50·7	200	The pulp was bleached in two stages without the intermediate alkali treatment. The brightness of the bleached pulp sheet was 62.
258	61·6	9640	3·9	66·5	52·5	260	The pulp was bleached in two stages with the same quantity of bleaching powder as in Serial No. 9*a* but with an intermediate alkali treatment. The brightness of the bleached pulp sheet was 69.

TABLE III

PILOT PLANT TRIALS

Strength properties of writing papers from a mixture of panni grass pulp and sabai grass pulp

The papers were conditioned at 65% R.H. and 80°F.

Property	Writing paper from a mixture of 75% *panni* grass pulp and 25% sabai grass pulp	Writing paper from a mixture of 60% *panni* grass pulp and 40% sabai grass pulp
1. Freeness, c.c. (C.S.F.)	161	156
2. Ream weight in lb., $17\frac{1}{2}'' \times 22\frac{1}{2}''$—500 ..	18·6	17·0
3. Basis weight*, g./sq. metre	62·1	56·9
4. Thickness, mils (1/1000 inch) ..	3·45	3·35
5. Tensile strength (Schopper), kg. per cm. width		
(*a*) Machine direction ..	2·20	2·14
(*b*) Cross direction	1·23	1·02
6. Breaking length*, metres		
(*a*) Machine direction ..	3540	3760
(*b*) Cross direction	1980	1790
7. Stretch, %		
(*a*) Machine direction ..	1·5	2·2
(*b*) Cross direction	2·4	3·7
8. Tearing resistance (Marx-Elmendorf), g.		
(*a*) Machine direction ..	32	32
(*b*) Cross direction	32	37
9. Tear factor*		
(*a*) Machine direction ..	51·5	56·2
(*b*) Cross direction	51·5	65·0
10. Bursting strength (Ashcroft), lb./sq. inch	4·2	16·6
11. Burst factor*	4·8	20·5
12. Folding endurance, double folds		
(*a*) Machine direction ..	7	17
(*b*) Cross direction	8	8

* For calculating this, oven-dry weight of the paper was used.

PROTECTION OF TIMBER, GRASSES AND TEXTILES AGAINST FIRE

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It is known that timber in cross-sections over 6 $\times$ 6 inches behaves under fire much better than steel. That is because steel structures quickly and easily twist, and are crushed under a load when exposed to high temperatures as from fire. An iron girder gives very little time for the occupants of a house on fire to clear out because the walls on which it rests are quickly thrown off due to the high coefficient of thermal expansion of iron. Timber, a cellulosic material, is no doubt combustible ; but it is consumed so slowly, in large sizes, that it continues to retain considerable strength[1] even after long periods of exposure to fire. Further, in its low coefficient of thermal expansion, more particularly in the direction of its grain, a wooden beam rarely causes collapse of the walls. But grasses and palmyra leaves which are used for roofing, catch fire easily and are destroyed almost instantaneously. Just as protection is given to these materials against deterioration due to biological causes—fungi and insects—they can also be protected against fire by suitable chemical treatments.

There are many chemicals[2] like boric acid, ammonium phosphate, zinc chloride, etc., which may be impregnated either singly or in suitable combinations to protect timber against fire. Some of the above chemicals like boric acid and zinc chloride are also toxic to insects and/or fungi. But, whenever timber is to be used in contact with the ground and in the open as in sleepers, more toxic salts of arsenic, nickel, and copper are used. And to prevent leaching of the chemicals from wood, sodium dichromate is employed. In the development of a suitable antiseptic-cum-fire-proofing composition for treatment of timber, care is necessary to weigh efficiency and cost, because heavy absorptions (3 to 10 lbs. of dry chemicals per cubic foot) have to be given. In this connection various compositions have been tested. While the Central Standards Office, Ministry of Railways, is interested in these experiments for the treatment of bridge sleepers, the Imperial Tobacco Company, Ltd., India, is interested in the treatment of thatch grasses, and palmyra leaves for roofing purposes. All the ingredients used in the above mentioned compositions are manufactured in this country.

Experiments have also been conducted to evolve a suitable paint from indigenous materials. Substances[3] like boric acid or borax, pulverized mica, asbestos powder, silica, fine gravel, soap stone, magnesium salts, gypsum, zinc oxide, sodium alginate, etc., are used in this connection. To this list may be added ashes of coal, timber, etc., which have now been found to be quite deterrent. Several compositions using some of the above materials have been tried. For inside locations, as in the case of mine props, cinema halls, etc., a suitable binding material such as gum arabic and/or tamarind seed powder has been used. For external use, synthetic resins, bituminous tars have been tried as binders. Messrs. John Taylor and Sons (India) Ltd., Managing Directors, Kolar Goldfields, are taking interest in these experiments.

Incidentally, the residual mineral wastes of mica, asbestos, etc., found lying at the several mines in the country will be immensely consumed, thereby increasing Government Royalty revenue.

A few results obtained are given below. Full details of the results of these experiments will be published shortly. These compositions have given satisfactory results with textiles also.

1. Fire-proof-cum-antiseptic composition

Boric acid	3 parts by weight
Copper sulphate	1 ,, ,, ,,
Zinc chloride	5 ,, ,, ,,
Sodium dichromate..	7 ,, ,, ,,

(Sodium dichromate can be varied from 6–7 parts depending on the species of timber).

Timber species tested	Absorption lbs. dry salt per cu. ft.	Resistance* to fire before treatment *a*	Resistance* to fire after treatment *b*	Efficiency of treatment *b/a*
Semul ..	6·24	13·65	74·4	5·5
	2·78	13·65	56·6	4·0
Chir ..	7·96	11·0	80·8	7·0
	2·79	11·0	67·5	6·0

2. Fire-proof Paints

Ashes	25 parts by weight
Mica powder	25 ,, ,, ,,
Borax	15 ,, ,, ,,
Asbestos powder	10 ,, ,, ,,
Zinc oxide	10 ,, ,, ,,
Tamarind seed powder	10 ,, ,, ,,
Gum arabic	5 ,, ,, ,,

(For plastering, lime or cement can be used as binders).

Timber species tested	Dry paint in gms./sq. cm.	Resistance* to fire before treatment *a*	Resistance* to fire after treatment *b*	Efficiency of treatment *b/a*
Semul ..	0·030	13·65	49·6	4·0
Chir ..	0·040	11·03	48·5	4·5

Experiments to test composition (1) as a general wood preservative under low absorptions are now under way.

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* The figures under "resistance to fire" indicate the percentage residual weight of timber after test by the well known 'Fire-tube' method[4]. These values are the average of six tests in each case.

STUDIES ON ADHESIVES

PART XVI.—PLYWOOD ADHESIVES FROM CASHEW NUT SHELL LIQUID

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SUMMARY

Cashew nut shell liquid to which 10% of phenol has been added can be condensed with formaldehyde in presence of ammonia. The resins so prepared when mixed with suitable "hardeners" (copper carbonate, activated charcoal, etc.) make satisfactory thermosetting plywood adhesives. The adhesive however requires longer curing times than phenol formaldehyde adhesives.

In Indian Forest Leaflet No. 111 cold setting adhesives from cashew shell liquid were described. These adhesives required para-formaldehyde for setting.

In continuation of these earlier experiments attempts were made to modify the formulations described therein for use as thermosetting adhesives. Further condensation of the acid polymer with formaldehyde appeared to give satisfactory results and these formulations are being further studied.

As para-formaldehyde is rather difficult to get, experiments were undertaken to develop thermosetting adhesives with formaldehyde or furfural, particularly for plywood work. The results so far obtained are briefly described in this note.

For these studies a commercial sample of cashew nut shell liquid was employed. The basic idea of these experiments was to develop adhesives from condensates obtained with formaldehyde or furfural with cashew nut shell liquid to which 10% of phenol had been added. A composition consisting of 90 parts of cashew shell liquid with 10 parts of phenol and 89 parts of formalin and 2·5 parts of liq. ammonia was not difficult to condense but the resin so prepared showed no adhesion to wood. However, various compounds were found to "harden" the resin so prepared. Therefore, a series of materials were tried as hardeners and fillers. Among those so far tried the following may be mentioned :—

(*a*) Lead oxide, sodium diethyl-di-thio-carbamate, gallic acid, ferrous sulphate, copper sulphate, calcium hydroxide, copper chloride, copper carbonate, boric acid, zinc chloride, tetra-naphthenoyl-triethylene polyamide, manganese dioxide and dinitro-chloro-benzene, copper acetate, copper oxolate.

(*b*) Wheat flour, prolamine, rubber latex.

(*c*) Sand, cement, charcoal.

Of these wheat flour, prolamine and sodium diethyl-di-thio-carbamate, gave satisfactory results and the best results were obtained with calcium hydroxide, copper chloride, activated charcoal, and copper carbonate. These were studied in greater detail for plywood production.

Usually the resin was prepared by condensing at 60–70°C. for 4 hours and dissolved in trichlorethylene. To this the hardener was added (5% on the weight of the resin).

The range of plywood glue adhesion values obtained with mango are given in Table I below :—

TABLE I

"Hardener" employed	Glue Adhesion: Dry — Failing load lb.	Glue Adhesion: Dry — Glue failure %	Glue Adhesion: Hot Wet — Failing load lb.	Glue Adhesion: Hot Wet — Glue failure %
MANGO VENEERS 1/16"				
Rubber latex (pressed at 140°–160°C. at 300 lb./sq. in. for 30 minutes). (18)*	177 to 214	80 to 95	91 to 190	100
Copper chloride (400 lb./sq. in. 140°–150°C., 25 minutes). (16)*	171 to 200	5 to 15	118 to 152	45 to 90
Copper carbonate (300 lb./sq. in. 165°C., 25 minutes). (9)*	188 to 238	1 to 40	115 to 170	75 to 100
Calcium hydroxide (200 lb./sq. in. 160°–170°C., 20 minutes). (15)*	202 to 229	30 to 100	80 to 138	100
Activated charcoal (300 lb./sq. in. 165°C., 25 minutes). (11)*	163 to 265	0 to 15	122 to 166	50 to 95
Wood charcoal (250 lb./sq. in. 170°C., 30 minutes). (6)*	166 to 217	0 to 100	85 to 157	60 to 100

* The figures in brackets indicate the number of boards tested.

Results obtained with the above "hardeners" with *pali* (*Dichopsis elliptica*) and *vellapine* (*Vateria indica*) veneers are given in Table II. Two boards were prepared and tested in each case.

TABLE II

"Hardener" used		Glue Adhesion: Dry — Failing load lb.	Glue Adhesion: Dry — Glue failure %	Glue Adhesion: Hot Wet — Failing load lb.	Glue Adhesion: Hot Wet — Glue failure %
Copper chloride	*Pali*	70	100	Delaminated	
	Vellapine	363	30	187	100
Calcium hydroxide	*Pali*	270	60	167	75
	Vellapine	266	65	172	70
Copper carbonate	*Pali*	270	15	110	100
	Vellapine	351	25	200	65
Wood charcoal	*Pali*	187	100	Delaminated	
	Vellapine	250	100	125	100
Activated charcoal	*Pali*	110	100	Delaminated	
	Vellapine	280	70	163	100

These results indicate that while the formulæ are quite suitable for *Vateria indica* they give poor results with *Dichopsis elliptica*. The reasons for this difference in behaviour is being investigated.

Results obtained with boric acid treated veneers (mango), etc., are given in Table III below : Two boards were prepared and tested in each case.

TABLE III

"Hardener" used	Glue Adhesion			
	Dry		Hot Wet	
	Failing load lb.	Glue failure %	Failing load lb.	Glue failure %
2% Boric acid solution applied to veneers, veneers dried and painted Pressed at 300 lb./sq. in., 160°C., 30 minutes				
Resin only	170	65	140	100
Copper chloride	188	0	193	25
Activated charcoal	180	100	Delaminated	
Copper carbonate	251	5	215	100
Calcium hydroxide	245	100	115	100
Zinc chloride	215	50	140	75
5% Boric acid solution applied to veneers, veneers dried and painted Pressed at 300 lb./sq. in., 160°C., 30 minutes				
Resin only	133	100	60	100
Copper chloride	309	10	187	100
Activated charcoal	204	70	85	100
Copper carbonate	325	20	205	80
Calcium hydroxide	255	65	65	100
Zinc chloride	225	100	140	60
2% Boric acid solid on weight of resin mixed with resin and hardener				
Resin only	186	100	122	100
Copper chloride	150	0	143	50
Activated charcoal	273	80	158	100
Copper carbonate	311	20	220	80
Calcium hydroxide	237	90	135	100
Zinc chloride	90	90	100	70

(*contd.*)

TABLE III—(*concld.*)

"Hardener" used	Glue Adhesion				
	Dry		Hot Wet		
	Failing load lb.	Glue failure %	Failing load lb.	Glue failure %	
5% Boric acid solid on weight of resin mixed with resin and hardener					
Resin only	166	100	Delaminated		
Copper chloride	289	0	212	80	
Activated charcoal	135	100	55	100	
Copper carbonate	178	100	60	100	
Calcium hydroxide	133	100	Delaminated		
Zinc chloride	90	100	70	100	
5% Zinc chloride solution applied to veneers, veneers dried and painted					
Zinc chloride + Resin	233	20	100	100	Zinc chloride 5% on the weight of resin.
Resin only	153	5	112	0	
2% Zinc chloride solution applied to veneers, veneers dried and painted					
Resin only	231	35	177	100	
Various polyamides were tried with the following results :—					
Resin and polyamides only ..	..	..	..	..	No binding.
5% Copper chloride-Tetro-naphthenoyl Triethylene tetramine 1% ..	179	10	172	70	(Tetro-naphthenoyl Triethylene tetramine).
5% Copper chloride-Naphthenoyl amide	235	0	198	100	Naphthenoyl amide.
Dearborn Polyamide 5% copper chloride	202	4	122	1	
Copper carbonate	177	0	110	60	

NOTE.—All the hardeners are taken at 5% on the weight of resin.

Some experiments were also tried with the dry resin in powder (or shavings) form as the adhesive. With copper carbonate as "hardener" satisfactory results were obtained.

All the above results indicate that satisfactory thermosetting adhesives can be developed from cashew shell oil. However, the disadvantages noticed are the comparatively long pressing times and rather heavy spreads required, and variable results obtained. Further experiments are in progress to see how far the nature of the cashew nut shell liquid (source, nature of production, etc.) affects the results. This will enable a standard specification for the oil to be drawn up, so that more uniform results can be obtained.

In a few preliminary experiments the production of saw dust boards with the resin was also investigated. Coarse saw dust mixed with 20–30% of resin was pressed at about ½–1 ton/sq. in. for 30 minutes. Boards so prepared had tensile strengths varying from about 1,000 lb./sq. in. to 2,500 lb./sq. in. and a modulus of rupture from 1,700 lb./sq. in. to 4,500 lb./sq. in. Further work is in progress.

VEGETATION CARTOGRAPHY*

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At the outset let me thank you most heartily for the honour you have done me in inviting me to this Conference as an observer and to take part in its deliberations, for it has given me an opportunity to come in contact officially with you all and to play my humble rôle as a botanist in planning future developments of forestry of our country.

The second reason why I welcome this invitation is that it has been given me an opportunity to come to you as a delegate for India of the International Sub-Commission on Vegetation Cartography of the UNESCO to which body I was elected last year at the VII International Botanical Conference held at Stockholm. As a member of that Commission I have to report to its President, Professor Gaussen of the University of Toulouse, France the views of this country on the method he has proposed for vegetation cartography. It is evident that I could not have found a better scientific Conference than this one to open a Symposium on this subject for in the consideration of this question, and carrying it out, it is the foresters who will be called upon to play the major rôle.

In opening this Symposium I may say at the beginning that I propose to put for your consideration two well-known modern methods of the mapping of vegetation. The first method of Professor Gaussen is based on the scale of 1/100,000 and is meant to map large vegetation formations like the forests, etc. ; the other of Dr. J. Braun-Blanquet on the scale of 1/20,000 is on the contrary, meant to map plant associations of a region which requires naturally a much larger scale.

The question of vegetation cartography or the mapping of vegetation arises as a corollary to the study of phytosociology, for it will at a glance show the distribution of particular plant communities of a region. It will at the same time give a geographical value to the descriptive plant sociology. Such maps are indispensable for precision, control and comparison of different plant communities.

The importance of cartography for forestry and agriculture and for national economy has been recognized long since and the first to emphasize it was J. F. Schouw in 1822. He recognized very early the application of phytogeography to agriculture and forestry, for in his monumental work on "Principles of General Phytogeography" he said that a good phytogeographical map can very often give a good bird's eye view of the productive capacity of a country and the possibilities of further expansion than a number of statistical tables, for a phytogeographical map gives the result between climate and vegetation and as such its knowledge would prevent huge waste of money.

Earlier Professor A. P. de Candolle of the University of Montpellier had undertaken in 1806 the study of phytogeography of France at the suggestion of his Government and completed his work in five years and wanted to add to it an atlas representing what he called the "botanical and agricultural regions" of France. Unfortunately De Candolle could not finish his work due to many reasons and it was not till the end of the last century that the question was retaken at Montpellier by Flahault. In 1894, Flahault read a paper before the Botanical Society of France on the "Problem of Cartography for Botany, Agriculture and Forestry of France" and he himself surveyed during 15 years 1/10th of France on the scale of 1/200,000.

However, the stimulus given by Flahault had good effect in Scotland, Switzerland, Germany and Austria where Smith, Schroter and Stiger took up the work. However,

* Paper presented to the VIII Silvicultural Conference, 1951.

Flahault's attempt at Cartography remains classic for it was he who for the first time introduced the fundamental principle of botanical cartography namely of *mapping groups of vegetation or associations, characterized by their specific species and not by individuals.* In short the fundamental basis of his cartography was the "Plant associations".

If Cartography is to be done on the basis of plant associations, then the question naturally arises, what are plant associations and which of them and how should they be represented on the map for, just as there is hierarchy in systematic botany, so also there is in phytosociology namely of associations, alliances, orders and classes.

This means that before a botanical map on the basis of plant associations is thought of being made, all the plant associations of that country should be first studied. Fortunately this work has been practically completed for France by Braun-Blanquet and published in his Prodromus.

The second question that arises is what scale would be more suitable for, experience in cartography has shown that a map on the scale of 1/20,000 to 1/25,000 is the most convenient, for on it sufficient details can be shown. This is now the official scale used in France, Germany and Switzerland.

The third question that arises in this work is that of the choice of appropriate colours. For this the following colours have been chosen because they can be reproduced or printed easily :

(i) Red and yellow : for prairies and other types of Xerophytic vegetation.

(ii) Blue and violet : for hygrophilous prairies.

(iii) Green : for forests.

On these principal groups of colours, different kinds of symbols are superimposed to distinguish associations, alliances, etc.

The colour scheme is drawn out according to the resolution adopted at the VIth International Botanical Congress held at Amsterdam in 1935. Accordingly to each order is given one colour but by lighter tints. The deepest colour is given to those alliances which are the least distributed so that they can be easily made out from the rest, viz., the alliance of *Deschampsictum mediœ* or the same principle is followed in the case of plant associations which approach the climax most, like the *Quercetum ilics.*

In each alliance, the associations are distinguished by special or different symbols in black which are superimposed on the colour alliance. For assuring the clarity of the map, it is desirable to limit the number and kinds of symbols so that the names of places or courses of rivers, do not get smudged.

In cases where an alliance has got only one association then there is no need of a special symbol to distinguish it from its alliance. However, where an alliance is comprised of many associations, then no symbols are used either for the association which has the largest distribution or is the most important association of that alliance. For other associations of that alliance different types of symbols like the following can be used :—round, circumflex accents, etc., whereas the black continuous dashes will be reserved for the associations which are least spread, so that they can be easily made out.

It is possible that a certain amount of confusion might occur due to the use of very similar colours. In order to avoid it and make the map clearer, the initials of the names of the associations might be superimposed on such colours, viz., Q.i for *Quercetum ilics,* Q.c for *Quercetum cocciferace*, etc.

The sub-associations might be represented by putting the symbols of the associations (more thickly or) more closely or by a distinct symbol as an independent association or by the first small (minor) letter of the sub-association.

The facies can be represented either by very fine dots or by capital letter of the name of the facies, viz., T for *Thymus vulgaris* facies.

If the colour representing an alliance or an order is very dark, then the symbols used might be in white to distinguish them clearly ; or these different symbols may be made thicker if they are retained in black.

Whatever colours are used or whatever symbols are employed, it must always be borne in mind that the chief aim of mapping should not be missed, namely clarity.

For further facilitating the work of mapping of the vegetation of France, certain colours are suggested for certain groups of association. For example :

(1) For associations of rocks—black.

(2) For associations of cultivated lands—grey or olive.

(3) For aquatic and hygrophilous associations—blue or violet.

(4) For Xerophilous prairies—orange or yellow.

(5) For forests—green.

(6) For littoral vegetation—bistre.

However, in certain cases or for special purposes, if the distribution of certain species is desired to be known, for example of *Tectona grandis* in a mixed deciduous forest, then special symbols for the species may be used which may be super-posed on the colours of the associations. In this case then, the same symbol would not stand for the same associations but for a particular species in which a forester is interested.

Or it is possible that one wants to know the distribution of certain species like those of the medicinal plants or rare species. These again can be represented by special symbols in black. These symbols may represent the form of that species, viz., circle, triangles, semi-circles, etc., or a tree may be represented by a trunk, shrubs by smaller trunks, herbs without trunks, etc. In principle, use similar symbols for closely allied species just as with colours for example if the oak is represented by a triangle, then modifications of the triangles should be used for all species of the oak.

However, the number of symbols used should be limited as far as possible, in order to avoid confusion. Finally comes the question of representing the initial or the regressive stages of an association.

The initial stages are represented by thin narrow vertical bands of the colour of the association concerned. The regressive stages are, on the other hand, represented by horizontal bands of the colours of the associations of which they form the regressive stages.

Many times mixtures of two associations occur in which case such mixtures are represented by alternating vertical broad stripes of the colours of the associations in question. And finally the mosaics, i.e., areas in which associations of, viz., *Rosmarinus officinalis* and *Quercus coccifera* occur together in such a way that neither of them destroy the other, then such a mosaic is represented by dots of colour of one association over the other. This is carried by having as the base the dominant association colour over which the other association is represented by its coloured dots.

It will be evident from what has already been said that the system of mapping on the basis of plant sociology requires preliminary classification on the basis of the floristic composition. This system, therefore, involves very detail study of the flora of a country and the final map that results out of it would indicate the micro habitat conditions, involving micro-climate, soil and the biotic factors.

On the other hand the system of Professor Gaussen which I will just describe to you has as its aims : (1) collection of economic data of the natural vegetation or as modified by man ; (2) information on the possibilities of the habitat which can be usefully employed for future exploitation. In short the map would be an inventory of the actual situation and a guide for its exploitation from the ecological knowledge gathered about the vegetation. Hence at this juncture when the U.N.O. is trying to find out the future agricultural possibilities of the different parts of the world, the map according to the system of Professor Gaussen would help enormously.

Realizing the importance of the habitat, Professor Gaussen has tried to combine in his map the habitat factors along with vegetation. However, he does not take into consideration all the factors but only the six following which are considered by him as essential and as directly controlling vegetation :—

(1) Temperature.

(2) Humidity.

(3) Xerothermic factor.

(4) Light.

(5) Type of vegetation.

(6) Kind of soil.

Other factors like wind, snow, etc., are considered as complimentry and are to be considered in special cases only.

Each of the above six factors Gaussen divides into a number of sub-divisions, each of which he represents by a symbol and a colour. For example temperature is divided into the following six divisions :

t_1	very cold as in the tundras ..	Represented by	dark-grey dots.
t_2	cold	,, ,,	light-grey.
t_3	moderately cold	,, ,,	white.
t_4	moderately hot	,, ,,	golden-yellow.
t_5	hot	,, ,,	orange-maroon.
t_6	very hot	,, ,,	orange-red-maroon.

Similarly he divides humidity into the following six sub-divisions :

h_1	very dry as in the Sahara ..	Represented by	orange-yellow.
h_2	dry as in Sargosse	,, ,,	pale-yellow.
h_3	moderately dry as in Marseilles ..	,, ,,	white.
h_4	slightly humid as in Paris ..	,, ,,	light-cobalt blue.
h_5	humid as in Tokyo	,, ,,	dark-blue.
h_6	very humid as in Buitenzorg ..	,, ,,	dark-violet.

The Xerothermic factor is defined as the duration of the dry season and is divided into four sub-divisions symbolized as follows :

X_1 a season of less than 50 dry days in the year—White.

X_2 a ,, ,, 50 to 100 dry days in the year—represented by thickly set chrome-yellow.

X_3 a ,, ,, 100 to 150 dry days in the year—represented by very sparsely set yellow.

X_4 a ,, ,, of more than 150 dry days in the year—represented by sparsely set yellow.

The light factor is divided into only three sub-divisions namely,

l_1	feeble light ..	.. light-grey.
l_2	moderate light ..	.. white.
l_3	intense light ..	.. light-pink.

The vegetation factor is divided into three sub-divisions and designated V_1 V_2 V_3 and the factor V_2 is sub-divided into V_2 and $V_{2/3}$.

V_1 a short vegetative season of less than 6 months—Large dots.

V_2 average vegetative season of 6 to 9 months—Uniform colour.

V_3 a season of continuous vegetation—Vertical indigo dashes.

And lastly the soil factor is sub-divided into 13 parts each indicated by a special symbol as follows :

H	for humid soil.
S	,, saline soil.
A	,, sweet water vegetation.
T	,, turbid or acid water vegetation.
M	,, sea water vegetation.
Sm	,, brackish water.
Ca	,, calcareous soil.
Ar	,, clayey soil.
Arl	,, lateritic clayey soil.
L	,, laterite.
$\Sigma\sigma$	,, sandy non-saline soils.
T	,, acid soils.
Hu	,, humus soils.

Each type of soil is again given special colour and symbol.

Thus by combining each of the above six factors into formulæ and representing them by different colours, Gaussen tries to depict types of vegetation both by symbols and colours. For example, a region of very cold climate with average light intensity is divided by him into two sub-divisions and represented as follows :

Acid tundras ..	.. $t_1\ h_3\ x_1\ l_2\ v_1$ T
Marshy tundras ..	.. $t_1\ h_5\ x_1\ l_2\ v_1$ T

Thus by following his system, any type of vegetation can be represented both graphically by colours and mathematically by symbols. If there are two similar types of vegetation

differing slightly as in the above case, then they would be represented by almost similar colours and almost identical formulæ, as in the above cases in which the formulæ differ only in the humidity factor.

As far as can be made out the above system of Gaussen is very elaborate and requires a thorough knowledge of the conditions of a region, since the sub-divisions of the factors are more or less arbitrary as he himself states.

The question, therefore, now before us is whether the above two systems, in your opinion, would work or not for India and if not, what modifications would you propose so that at the next meeting of the International Commission on Vegetation Cartography in 1954 I may place before it your views and suggestions for consideration.

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LANNEA GRANDIS, ENGLER

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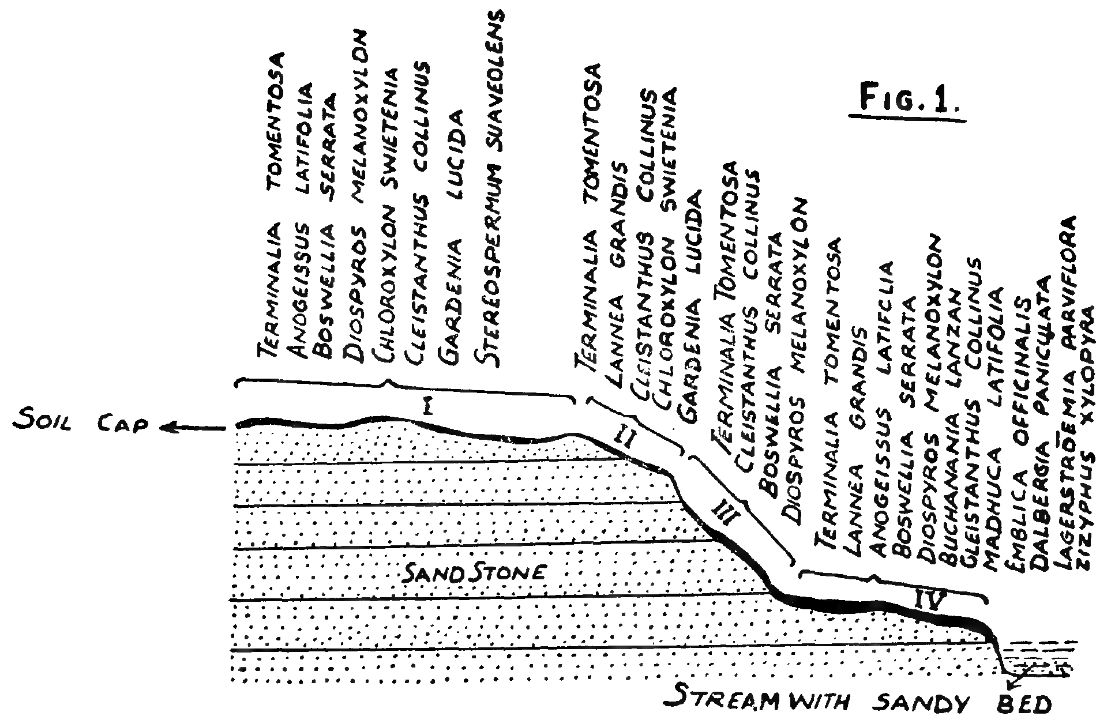
I read with interest, *Dr. K. Kadambi's* paper on *Lannea grandis* which appeared in *Indian Forester*, Vol. 76, No. 12 (December 1950), pp. 529–538. Especially with regards to South Raipur Division, Madhya Pradesh, I want to bring out some facts, which may be of some interest.

In South Raipur Division, *Lannea grandis* is termed as *Modga* by *Kamars* and *Gonds*.

In his aforesaid paper, *Dr. Kadambi* states that in Madhya Pradesh the tree generally attains a small size except in the hills where, on shady slopes, it may attain a girth of 6 feet. It occurs throughout the South Raipur Division, where, however, it attains good dimensions in South Sihawa range only. This remark is only partly true and needs clarification and modification. When *Dr. Kadambi* says that it attains good dimensions in South Sihawa range only, it at once points out to the fact that *Dr. Kadambi's* source of information is pretty old. Prior to 1923, the sal ranges of South Raipur Division were worked as two administrative units, viz., North Sihawa and South Sihawa ranges. But with the introduction of *Shri C. M. Harlow's* plan in 1924, these two ranges were split up into four, viz., Nagri and Birguri ranges constituting the old North Sihawa range and Risgaon and Sitanadi ranges comprising the old South Sihawa range. Since then, the South Raipur sal forests are being worked under these four administrative charges, viz., Nagri, Risgaon, Sitanadi and Birguri ranges and the old North and South Sihawa ranges have disappeared long ago.

South Raipur Division consists of two distinct sub-divisions, viz., mixed ranges (Balod and Dhamtari ranges) and sal ranges (Nagri, Risgaon, Sitanadi and Birguri ranges). Mixed ranges carry predominantly the miscellaneous forest of usually poor quality, with some scattered patches of teak on suitable localities. *Lannea grandis,* though it forms quite a conspicuous constituent of the crop, it follows only certain well-defined topographical features. The geological formations here, are sandstone (violet, yellow and silicious sandstone) and bedded quartzites of Cuddapah series. The dip of the rock is negligible and the topography is usually ragged with flat-topped isolated hillocks and extensive low plateux. Therefore, the disintegration of rock is a very slow process and soils of any depth are found only along gentle slopes and in valleys where they have been washed down. On these geological strata, *modga* (*Lannea grandis*) confines only to the upper slopes of hillocks and plateux and in the valleys. The characteristic diagrammatic representation is given in *Fig. 1.* The hill-tops and plateux (I) which have a very thin layer of sandy, dry and mostly infertile soil, carry the characteristic tree vegetation of *Terminalia tomentosa, Anogeissus latifolia, Boswellia serrata, Stereospermum suaveolens, Diospyros melanoxylon, Chloroxylon swietenia, Cleistanthus collinus, Emblica officinalis* and *Gardenia lucida.* Other associated species are *Acacia catechu, Bauhinia retusa, Casearia graveolens, Bridelia retusa* and *Erythrina suberosa.* Here, *modga,* is conspicuously absent. The upper slopes (II) which are usually not steep and have a better accumulation of soil but still very arenaceous and dry, carry *Terminalia tomentosa, Lannea grandis, Cleistanthus collinus, Chloroxylon swietenia* and *Gardenia lucida,* as the main crop constituents. Here *modga* makes its appearance, possibly due to better humic ingredients in the soil. The growth of *modga,* however, is very poor. It usually attains a height of 35 feet and 26 inches girth. The clear bole is 15 feet but mostly well formed. *Modga* on these slopes leaves and flowers nearly one month earlier than elsewhere. The steep slopes (III) which, though have a sufficient depth of soil, contain a good amount of rock fragments and the humified top layer of soil

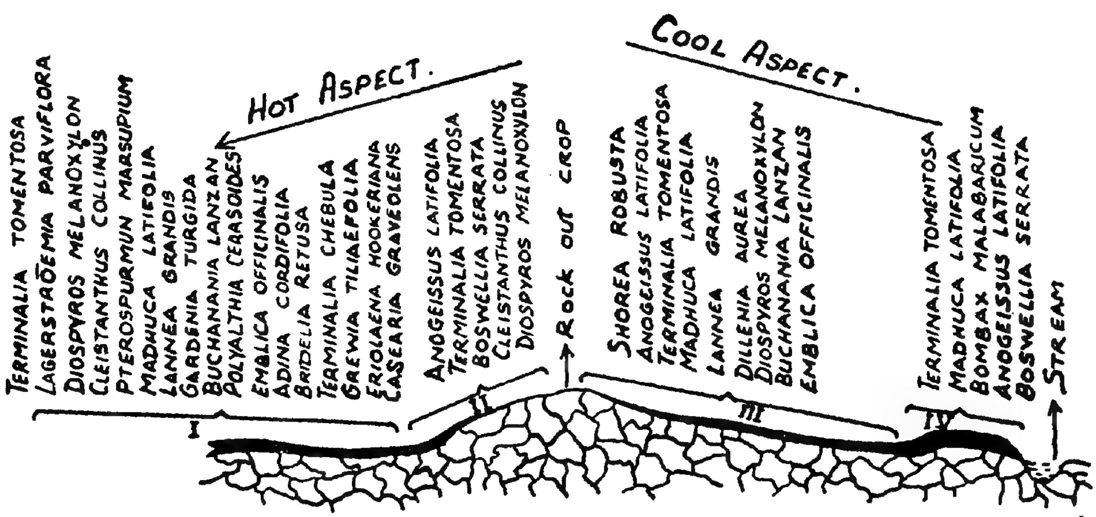


is much thinner. Here, again, *modga* is absent. The main crop constituents being *Terminalia tomentosa, Cleistanthus collinus, Boswellia serrata* and *Diospyros melanoxylon*, with some *Gardenia lucida*. On lower flat stretches in valleys (IV), the soil is deep (2′–3′) and with greater proportion of argillaceous matter and a better developed humified top layer. Soil moisture content is also higher than in the rest of the area. Here *modga* attains better dimensions. Its height is 55 feet and girth 3½ feet. The main crop constituents are *Terminalia tomentosa, Lannea grandis, Anogeissus latifolia, Boswellia serrata, Diospyros melanoxylon, Buchanania lanzan, Cleistanthus collinus, Madhuca latifolia, Emblica officinalis, Dalbergia paniculata, Lagerstrœmia parviflora* and *Zizyphus xylopyra*. The less frequently occurring species are *Adina cordifolia, Pterocarpus marsupium, Stephegyne parvifolia, Terminalia belerica, Terminalia chebula, Grewia tiliæfolia* and *Cassia fistula* and only occasionally occurring ones are *Acacia lenticularis, Schleichera oleosa, Ougeinia dalbergioides, Schrebera swietenioides, Albizzia lebbek* and *Acacia catechu*. Here *modga* forms part of the upper canopy and successfully competes with other species. It may be mentioned here that these mixed forests are subjected to heavy grazing and uncontrolled annual fires, and as such these adverse factors have temporarily arrested the progressive development of a higher vegetation climax in which, probably, *modga* will have a very conspicuous place. In the present stable sub-climax, however, *modga* is just an accessory species.

In sal ranges (Nagri, Risgaon, Sitanadi and Birguri) where geological rocks are mostly massive granites, syenites and dioritic rocks, particularly without any foliation. Gneiss, schists and arkose are common, but, by far, the greater portion is covered with hornblende gneiss. Pegmatite occurs only locally. Here the country-side is mostly flat with isolated hills scattered. The soils are deep, red and yellow loams with moderate moisture contents and a well-developed humified top leayer. Here sal forest is the predominant feature but mixed forest also covers sufficiently big stretches in Nagri and Birguri ranges. *Modga* occurs both in

mixed and sal forests. In mixed forest, however, it is one of the principal species, usually in the top canopy and in the sal forest it occurs only sporadically and in the understorey. The diagrammatic occurrence of *modga* in sal ranges is shown on *Fig. 2.*

FIG. 2.



On the hotter aspects and on the lower slopes (I) where soil is deep and clayey, the predominant species in the top-storey are *Terminalia tomentosa*, *Lagerstrœmia parviflora*, *Pterocarpus marsupium*, *Madhuca latifolia*, *Lannea grandis*, *Adina cordifolia*, and *Terminalia chebula*. In the underwood the main species are *Diospyros melanoxylon*, *Cleistanthus collinus*, *Gardenia turgida*, *Buchanania lanzan*, *Polyalthia cerasoides*, *Emblica officinalis*, *Grewia tiliæfolia*, *Eriolœna hookeriana* and *Casearia graveolens*. *Modga* forms 5 per cent of the crop and attains a height of 70 feet and girth 5 feet. Natural regeneration of *modga* is prolific, specially under moderate shade. The hill-tops and the upper slopes of hot aspect (II) carry mostly *Anogeissus latifolia*, *Terminalia tomentosa*, *Boswellia serrata*, *Cleistanthus collinus* and *Diospyros melanoxylon*. *Modga* is absent. On the cool aspects (III) where soil is more deep, humified and moist, sal forest with common associates of *Anogeissus latifolia*, *Terminalia tomentosa* and *Madhuca latifolia* in the top canopy and *modga*, *Dillenia aurea*, *Diospyros melanoxylon*, *Buchanania lanzan* and *Emblica officinalis* in the understorey, are of frequent occurrence. Occasionally near stream banks, on deep alluvium mixed forest of high quality is found. The main crop constituents, here, are *Terminalia tomentosa*, *Madhuca latifolia*, *Anogeissus latifolia*, *Boswellia serrata* and *Bombax malabaricum*. *Modga* is absent. Though *modga* occurs only as an accessory species in the underwood of sal forest and usually attains a height of 50 feet only, the girth increment is by far, the best. Occasional trees of 8 feet girth may be seen here.

These observations indicate that *modga* needs following optimum conditions for normal growth :

(*a*) A moderately deep soil with a fair amount of humus infiltration.

(*b*) Usually a moderately sloping ground.

(*c*) Only light soil moisture content.

(*d*) It needs moderate shade during its regeneration and establishment period.

(*e*) Full over-head light from sapling stage till it becomes middle-aged. During this period it attains maximum height growth.

(*f*) Moderate over-head shade in the latter half of the life or protection from hot sun and winds.

Natural regeneration of *modga* occurs only on deep soil but on both hot and cool aspects. On hot aspects, however, under the light shade of miscellaneous species, the seedlings get a chance to establish and attain fair height. On cooler aspects in sal forest, regeneration does occur but the plants do not grow to any appreciable height. They, however, produce big carrotty roots. Once the sal forest is clear-felled under the conversion system, *modga* becomes a conspicuous crop constituent in the second growth forest. But being a slow grower, lags behind in the height growth, and in a 25 years old sal forest, *modga* is distinctly below the general top canopy.

Seed dispersal is mainly by crows. They eat the fruits as a whole and the seeds in faeces are thrown far away from the mother trees.

In mixed forest *modga* is only a moderate coppicer and gives on an average 2 shoots per stool, but more frequently only one. On drier, upper hill slopes it does not coppice at all. In mixed forest of sal ranges it usually gives 2–3 shoots per stump, and in sal forest as many as 5 shoots per stool may be seen.

The rate of growth of unthinned coppice *modga* in mixed ranges is as follows :—

Age	Badbhum F.S.		Chirchari F.S.		Narragaon F.S.		Dhanapuri F.S.		Dongimacha F.S.		Kassawahi F.S.	
	Height *ft.*	Girth *in.*	Height *ft.*	Girth *in.*	Height *ft.*	Girth *in.*	Height *ft.*	Girth *in.*	Height *ft.*	Girth *in.*	Height *ft.*	Girth *in.*
1	2	3	2	3	2	3	2	3	2	3	2	3
5	7·0	4·4	6·8	4·3	12·1	3·0	6·8	5·1	1·4	2·1	5·6	6·1
10	10·0	6·1	9·2	5·5	15·3	6·0	11·9	10·1	3·1	4·9	8·0	7·3
15	12·2	7·8	12·3	6·8	20·5	10·0	16·1	12·1	7·4	7·8	11·5	8·1
20	14·9	9·7	13·9	8·5	24·8	13·8	19·9	14·8	11·3	10·2	14·6	10·2
25	20·0	13·3	19·2	11·3	29·4	17·3	23·1	17·0	14·4	11·3	17·3	11·4
30	26·0	16·3	25·6	14·4	32·3	20·4	24·5	17·9	16·8	13·3	19·5	13·4
35	31·0	19·0	30·4	17·2	34·4	23·3	24·9	18·2	18·3	14·2	20·1	14·7
40	34·0	20·8	33·3	18·9	35·4	25·8	25·3	19·0	21·2	15·3	20·7	16·8

Similar figures from sal ranges are not available.

(The above felling series lie in Champion's South Indian dry deciduous forest type which has a typical height of 50–75 feet).

As regards the management of this species, no prescriptions were ever laid down in South Raipur Working Plans to preserve or to tend it. Usually it was regarded as inferior species and often hacked down indiscriminately, to favour such species as *Terminalia tomentosa*, *Pterocarpus marsupium*, *Adina cordifolia*, *Ougeinia dalbergioides*, etc. It is only in recent years that under the executive orders of the Chief Conservator of Forests, Madhya Pradesh, *modga* is being preserved to some extent as a plywood species.

GURCHARAN OR WOODLAND PROTECTED FORESTS IN THANA (BOMBAY STATE)

BY S. R. UMBARJE, B.A., A.I.F.C.

SUMMARY

The paper deals with the protected forests in the Thana District of Bombay State which are under the dual control of the Revenue Department as well as the Forest Department. A short history of its management in the past is given. Causes for their deterioration are discussed and remedies are suggested.

Forest Officers are familiar with the procedure of bringing an area under the Indian Forest Act and the classification of forest areas and these need no further elucidation. They are aware that the forests are divided broadly into two (1) Reserved Forests and (2) Protected Forests. The latter are either in charge of the Forest Department or the Revenue Department. Usually the protected forests are laden with innumerable privileges. This paper is concerned with the latter, i.e., the protected forests in charge of the Revenue Department known as *Gurcharan* or Woodland protected forests. My remarks are based on the experiences gained in the North Thana Division and I presume they are also applicable to the other two Thana Divisions.

2. The total area of woodlands is about 375 sq. miles and they are found generally wedged in between the village cultivation and the reserved forest in practically every nook and corner of the district. Being easily accessible the agricultural population exercise a large and varied number of privileges, the worst amongst them being "*Tahal* Cutting" which is against all the tenets of Silviculture.

3. The woodlands have been declared "Woodland Protected Forests" under several notifications, the earliest being 4 F., dated 1st March, 1879 and the latest being 43/28(*a*), dated 23rd September, 1933.

4. Prior to 1938–39 these forests were never worked under a regular Working Plan. In the earliest period a large part of the woodlands was felled under a scheme of removing Teak in four instalments the oldest being removed first. In 1918, it was supplanted by the clear cutting of Teak. *Injaili* trees were left to take care of themselves. In 1938–39 the present Working Plan was introduced. It must be said to its credit without pointing out its defects that this put the woodlands under a systematic management.

5. The forests as a whole come under the main type of moist deciduous type of forests. The growth is akin to that of the Reserved Forests, Teak and *Ain* (*Terminalia tomentosa*) predominating. Occasionally one finds a pure crop of Teak or pure crop of *injaili*. The poorest quality of forests is found in woodlands situated in non-forest villages or in villages where the reserved forest is small in extent and consequently the woodlands have been subjected to great pressure by the surrounding population. The woodlands have practically disappeared on the coastal tract. Due to constant hacking of trees especially *Ain*, the trees develop knots and burrs which produce better type of charcoal and is more valued than the charcoal produced in the Reserved Forests.

6. Till 1929 all woodlands which had been notified as protected Forests remained in the sole charge of the district, *taluka* and village revenue officers, and of the villagers themselves

without any interference of the Forest Department. It was subsequently changed by Government in G.R.R.D. No. 9811 of 10th July, 1929 which reads as follows :—

> "For the sake of making rules about trees all woodlands have been notified as protected forests ; but they are to remain primarily under the management of the Collector and his revenue staff, with such assistance in management and protection as the Forest Officers are able to give. The Forest Department will also be concerned with the felling for commercial purposes of the teak and in some cases of a proportion of the *injaili*, all the proceeds of such felling being credited to that Department".

7. It will be in the fitness of things to give below an extract of remarks of the Working Plan Officer embodied in the current Working Plan which summarises the management and control of the woodlands.

"The same resolution led to the appointment of a Forest Officer, as "*Gurcharan* Officer" under the Collector of Thana, to assist the latter in the improvement of the management of *Gurcharan* lands or woodlands in the Thana District. The staff of the Revenue Department which is responsible for the management of woodlands consists of *Mamlatdars*, *Mahalkaris*, Circle Inspectors and *Talathis*. They look to the conservancy of tree growth in woodlands, the inspection and maintenance of the boundaries of woodland plots given out for cultivation, the laying out of new woodland plots and the collection of assessment on the woodland plots. The Forest Officers occasionally assist the Revenue Officers by detecting and reporting offences. The subordinate staff of the Revenue Department has been reduced by 10 per cent, in 1932 and in spite of all the assistance given by the Forest Department, the problem of the conservancy of tree growth in woodlands and the regulation of privileges has not yet reached a satisfactory solution. The *Gurcharan* Officer has not been provided with a staff to assist him, as originally contemplated when the appointment was made. The revenue subordinates, accustomed as they are mostly to desk work and not provided with the necessary equipment (boots and uniform) to facilitate the inspection of forests, are obviously unfit to inspect the forests and detect offences. The *Mamlatdar* and *Mahalkaris* are too heavily encumbered with magisterial and revenue duties to find time to pay any serious attention to woodlands. It is, therefore, difficult for the *Gurcharan* Officer without the assistance of a trained staff to improve the management of woodlands as directed by Government. Immediately the Working Plan comes into force the woodlands, for all practical purposes, will come under the dual control of the Revenue and the Forest Department. The latter will be concerned with the felling and removal of the forest material, the raising of plantations and thinnings, etc., but the enforcement of provisions of the Working Plan, the most important of which are the closure of the annual coupes to *tahal* lopping and to grazing by sheep and goats, on which the success of the whole scheme depends, and the general conservancy of the woodland areas, will fall on the shoulders of the Revenue Department. When the woodlands, could not be looked after, by the Revenue Department in the past, it will be much more difficult for them to exercise the necessary supervision over them when a regular Working Plan comes into force. It is, therefore, necessary to have, in addition to the staff that the Forest Department will require to carry out the fellings and plantations as prescribed in this Working Plan, a separate batch of trained men under the Revenue Department to enforce the closure to *tahal* lopping, grazing, etc. This would mean double staffing and duplicated expenditure. It is, therefore, unfortunate that this dual control should be continued when the proposed forest staff is in a position to protect woodlands much more efficiently than the Revenue staff".

8. As stated above the *Gurcharans* once contained a magnificent growth which is slowly being depleted of valuable trees and the time will not be far off when there will be no trees left in these areas. At present these areas give an appreciable revenue to Government

and if no action is taken to stem its disappearance the Government should be prepared to loose it in the near future. Between 1927 and 1937 the revenue realized in North Thana Division varied from Rs. 18 to 92 per acre. It rose considerably during the 2nd World War and the maximum revenue realized was Rs. 258 per acre in 1948–49. This is quite an appreciable amount.

9. Following factors are mainly responsible for the disappearance of tree growth from the woodlands.

(*a*) Indiscriminate and unrestricted exercise of privileges by local population.

(*b*) Indiscriminate sanctioning of plots for cultivation.

(*c*) Inadequate staff for the control and management.

(*d*) Dual control.

(*e*) Absence of provision for regeneration after removing the main crop.

(*f*) Illicit cutting and delay in disposal of offence cases.

10. (*a*) *Indiscriminate and unrestricted exercise of privileges by local population.*— Numerous privileges sanctioned to the local population have been embodied in the Thana Woodland Code which need no repetition. Amongst these, *tahal* cutting and grazing are the most pernicious and damaging privileges and need careful examination. It has been the practice to burn the soil in seed beds for cultivation of rice, Nagli and Varai. The rab material is usually arranged on the seed bed in three layers, of which the upper two are earth and grass and in the lowest, the most important, is either cowdung, tree loppings, bushes or leaves. It is generally recognized that cowdung gives the best results but tree loppings are a good second. On account of the comparative scarcity of cowdung, the multiplicity of its uses and the risk of overmanuring or undermanuring the seed bed with it, tree loppings necessarily become by far the most useful and generally used manure in the Thana District. Till recently *tahal* was available in plenty and its dearth was never felt. But with the settlement of Forests, prevention of *tahal* cutting in the Reserved Forests, unrestricted felling of *malki* forests and disappearance of trees from woodland cultivation plots pressure of *tahal* cutting on the existing trees has been increasing steadily and time will come when we will be forced to allow this privilege in the reserved forest as well unless some prompt action is taken either to regularise it or to find an alternative for it.

11. The main idea behind framing the Woodland Code in 1905 was to regulate the exercise of privileges in woodland. Para 12 of the Thana Woodland Code directed that the woodlands should remain in charge of Revenue Officers and of the villagers themselves without any interference from the Forest Department. To bring the *tahal* cutting rules into practice, the general idea of which is to prevent or at least retard the destruction of tree growth which *tahal* cutting involves, an intense *tahal* cutting campaign was started with the object of educating the people to the advantages of treating tree growth considerately when cutting *tahal* for wood ash manure. The services of officers and subordinates of every Department were requisitioned to give field demonstrations. Even timber and charcoal merchants were pressed into service. This put an end for the time being the ruthless destruction of *tahal* producing trees. After a few years this enthusiasm waned and once the supervision was slackened the *tahal* users returned to their old and pernicious methods of lopping leading shoots which resulted into the gradual destruction of several woodlands. In this connection I may point out that the Agricultural School at Kosbad carried on experiments of raising seedlings on beds without using *tahal* and they have proved that seedlings grown from beds without using *tahal* for manure gave even better results and greater yield. Such experiments are to be demonstrated throughout the district to educate the people and propaganda is required to persuade them to give up this practice. If these fail, *tahal* cutting will necessarily have to be

stopped by law and the Government would have to be moved to take this beneficial step if further destruction of woodlands is to be prevented.

12. Next comes grazing. Cattle population has been increasing steadily in the Thana District and in recent years has assumed unmanageable proportion. One glance at the number of cattle in any village will show without any shadow of doubt that, not only their number is abnormally large but 90% of these are not useful for any purpose. Since they are let loose every day for grazing they are not useful even for producing manure. With unrestricted grazing the cattle population is not only converting the soil unfit for anything but they are responsible for destruction of young regeneration in the reserved forests. This is to be actually seen to believe. The Government will have to get at the root cause of this. With all my respect to all those who advocate protection of animal life I am of the firm opinion that unless the number of cattle is restricted per agricultural family by law, there would neither be any improvement in the condition of cattle nor the problem of grazing would be solved.

13. (*b*) *Indiscriminate sanctioning of plots for cultivation.*—The last two census reports have clearly shown how the population in India has increased already and has been increasing considerably. The Thana District is not an exception to it. With the increase in population, pressure on land for cultivation has increased considerably. The local villagers finding cultivation of plots in woodlands, where the soil is more fertile, easy and more paying try to get plots by every means with the result the woodlands are riddled with cultivation plots. Once a plot is sanctioned the cultivator kills the trees in the plot slowly and mercilessly to get more area for cultivation. Thanks to the Government in the Agriculture and Forests Department who passed an order in their G.R.R.D. No. 3781, dated 11 November 1950 that the Forest Department should be consulted before sanctioning a plot this has to a certain extent checked sanctioning of plots freely. Existence of woodland plots scattered all over the area not only reduces the effective grazing area for village cattle but restricts their movement especially in the rainy season. This has resulted in greater pressure of grazing in the reserved forest. Further sanctioning of plots would have to be stopped and the existing ones should be thoroughly examined for their discontinuance.

14. (*c*) *Inadequate staff for the control and management.*—It is already mentioned in one of the paras above that the Forest Department does not interfere with the management of woodlands. With the increase of various works in all directions the revenue staff is overworked and it is said that they are unable to cope up even with their more urgent and day to day routine work. It is, therefore, too much to expect them to exercise any control over the woodlands. The Working Plan provides for the minimum staff for the Forest Department for the disposal of trees and this has been implemented by Government. But this is not sufficient. With one Ranger, four Foresters, and eight Guards for the whole Division one cannot expect the Forest Department either to exercise control or detect offences. This has resulted into the woodlands being considered as nobody's or everybody's property. In order to exercise better control over these areas much more staff than at present is absolutely necessary. It will be a false economy if the Government refuses to consider this under the present scheme of drive for economy.

15. (*d*) *Dual Control.*—This has been adequately dealt with in the above paras and needs no further elucidation. With the dual control each Department puts the responsibility on the other which has resulted into slackening of efforts to exercise control or to regularize the privileges. Dual control is responsible for the present state of affairs. In my opinion the Forest Department should be entrusted with the full control of woodlands and the Revenue Department should be divested of all its control so far as the woodlands are concerned. This step will go a long way to preserve whatever little is left.

16. (*e*) *Absence of provision for regeneration in the present Working Plan.*—It is the most important principle of management that whatever is removed has to be replaced preferably with more. The Working Plan for Thana woodlands has conveniently omitted to provide for regenerating the areas. With the dual control inadequate staff and no funds nothing is done to reboise these areas once a crop is removed. With the existing privileges of unrestricted *tahal* cutting and grazing the villagers do not allow either the regeneration to come up or coppice shoots to thrive. Some provision is necessary to raise a concentrated plantation in a certain percentage of each coupe worked every year. Without this provision it is hoping against hope to expect any fresh tree growth in these areas.

17. (*f*) *Illicit cutting and delay in disposal of offence cases.*—The factors so far discussed are sufficient to show how the illicit cutting is taking place on a large scale and how the culprits go unpunished. The Forest Officers are prevented from dealing with offences committed in the woodlands. If they are empowered to deal with them as is done in the case of reserved forests I am sure considerable headway can be made in checking this illicit cutting. The Forest Officers are expected to help the Revenue Officers in checking the offences but as pointed above every Department tries to shirk its responsibility. The plea of the Forest Officers is that though the offences are detected and reported to the Revenue Offices the matter is delayed so long that the importance of the offence is lost and for want of timely punishment the villagers are encouraged to commit more offences. It has been my experience that in many cases the decision taken and the result of offence cases are never intimated to the Forest Department. No regular procedure has been prescribed for dealing with the offences committed in the woodlands. With the little vigilance on the part of the subordinates the result achieved in detecting offences can be seen from the following figures of offences detected in the woodlands for the last three years.

Year		*No. of offences detected*
1948–49	..	26
1949–50	..	4
1950–51	..	192

It is, therefore, proposed that the Forest Officers should be empowered to deal with the offences committed in the woodlands and the same procedure as in the case of offences committed in the Reserved Forest should be prescribed, if possible through the legislation.

18. To sum up, the woodlands are in a sorry and poor state. Considerable damage has already been done to them and their further destruction has to be prevented at all cost. The remedies have been suggested in this paper. The Government should be apprised of the present state of affairs and they should be persuaded to adopt a bold policy to prevent further destruction of this valuable property of the Nation before it is too late. The remedies may be further summed up as under :—

(i) Stopping of the privilege of *tahal* cutting completely or its regulation.
(ii) Restriction of the number of useful cattle per agricultural family.
(iii) Prevention of giving any more plots for cultivation.
(iv) Systematizing, the existing woodland plots or their total discontinuance.
(v) Provision of adequate staff for the woodlands.
(vi) Abolition of dual control.
(vii) Handing over entire management and control to the Forest Department.
(viii) Adequate provision for regeneration and subsequent silvicultural operations in the woodlands.

SOME USEFUL STATISTICS FOR THE FOREST OFFICER IN INDIA

STATEMENT I

Land Utilization Statistics, 1948–49

All-India Summary

	Particulars	Thousand acres	Square miles
1.	Geographical Area according to Surveyor General of India	810,811	1,266,892
2.*	Area according to village papers for which returns exist (Totals of 3 to 7)	577,731	902,705
3.	Area under forests	83,691	130,767
4.	Area not available for cultivation	93,044	145,381
5.	Other uncultivated land excluding current fallows	93,308	145,794
6.	Fallow land	62,394	97,491
7.	Net area sown	244,308	381,731
8.	Area sown more than once	33,576	52,463
9.	Gross area sown	277,884	434,194
10.	Cultivable area included in item No. 5 above ..	7,515	11,742
11.	Net irrigated area	46,988	73,419
12.	Gross irrigated area	49,947	78,042

* Includes 9,86,000 acres for which details under items 3 to 7 are not available.

Source :—Directorate of Economics and Statistics, Ministry of Food and Agriculture, Government of India.

STATEMENT II

Forest Area Statistics, 1948–49

All-India Summary

	Particulars	Square miles	Percentage
1.	Total forest area (Total of 2 to 4) ..	242,104	(19·1% of land area)
2.	Forest area owned by the State ..	182,539	(75·4% of forest area)
3.	Forest area owned by Corporate bodies ..	1,369	(0·6% of forest area)
4.	Forest area owned by Private individuals	58,196	(24·0% of forest area)
5.	Forest area under the control of Forest Departments	171,257	(70·7% of forest area)
6.	Forest area which is Merchantable ..	*	(About 60% forest area)

* In an area of 2,27,951 sq. miles for which reports exist, the area classified as 'Merchantable' and 'Unprofitable or inaccessible' are 1,34,277 and 93,674 sq. miles or 59 and 41% respectively.

Source :—Directorate of Economics and Statistics, Ministry of Food and Agriculture, Government of India.

STATEMENT III

Out-turn of Timber and Fuel, 1948-49

All-India Summary

1.	Area under the control of the Forest Department for which out-turn statistics are available	146,953 sq. miles
2.	Out-turn for the area in item 1	356,013,000 cu. ft.
3.	Out-turn per square mile of the area in item 1	2,423 cu. ft.
4.	Out-turn per square mile of 'merchantable' area in item 1..	4,038 cu. ft.
5.	Out-turn per capita	1·1 cu. ft.

Basis for estimations in items 4 and 5

4. 'Merchantable' area is estimated to be 60% of the area in item 1.

5. Calculated by dividing the out-turn figure given in item 2 by 337·75 millions, which is the 1951 Census population for those States whose figures are included in item 1.

Source :—Directorate of Economics and Statistics, Ministry of Food and Agriculture, Government of India.

STATEMENT IV

Per captia consumption of Round wood Average of (1947-49) in cu. ft.

World Summary

Groups of countries	Timber	Fuel	Total
1	2	3	4
Europe	13·77	14·83	28·60
North and Central America ..	57·56	13·77	71·33
South America	5·30	42·37	47·67
Africa	1·41	7·77	9·18
Asia	1·77	2·12	3·89
Oceania	32·84	31·78	64·62
Total*	12·36	9·18	21·54
India	0·35	0·71	1·06

* Excluding U.S.S.R.

Source :—Table 42 of Year-book of Forest Products Statistics 1950 (FAO).

STATEMENT V

Total forest area classified by ownership during 1948–49 (sq. miles)
Details by States

State	State forests	Forests owned by corporate bodies	Private forests	Total forest area	Total land area	Percentage of total forest area to total land area
1	2	3	4	5	6	7
1. Assam	20,948	501	474	21,923	85,007	25·8
2. Bihar	2,727	..	11,173	13,900	70,330	19·8
3. Bombay	17,330	5	169	17,504	1,11,434	15·7
4. Madhya Pradesh	19,414	..	21,493	40,907	1,30,272	31·4
5. Madras	18,825	..	14,871	33,696	1,27,790	26·4
6. Orissa	2,874	..	1,678	4,552	60,136	7·6
7. Punjab	4,873	..	..	4,873	37,378	13·0
8. Uttar Pradesh	18,277	521	3,076	21,874	1,13,409	19·3
9. West Bengal	2,680	41	1,110	3,831	30,775	12·4
10. Hyderabad	9,455	..	..	9,455	82,168	11·5
11. Jammu & Kashmir ..	11,058	..	..	11,058	92,780	11·9
12. Madhya Bharat	11,153	..	3,000	14,153	46,478	30·5
13. Mysore	4,448	66	47	4,561	29,489	15·5
14. P.E.P.S.U.	192	..	139	331	10,078	3·3
15. Rajasthan	12,782	..	..	12,782	1,30,207	9·8
16. Saurashtra	631	..	..	631	21,451	2·9
17. Travancore-Cochin ..	3,065	..	..	3,065	9,144	33·5
18. Ajmer	73	235	285	593	2,417	24·5
19. Bhopal	1,209	..	341	1,550	6,879	22·5
20. Bilaspur	200	..	..	200	453	44·2
21. Coorg	829	..	327	1,156	1,586	72·9
22. Delhi	..	..	..	..	578	..
23. Himachal Pradesh ..	2,999	..	13	3,012	10,451	28·8
24. Kutch	169	..	..	169	16,724	1·0
25. Manipur	2,250	..	..	2,250	8,628	26·1
26. Tripura	3,610	..	..	3,610	4,032	89·5
27. Vindhya Pradesh ..	7,968	..	..	7,968	23,603	33·8
28. The Andaman & Nicobar Islands	2,500	..	..	2,500	3,215	77·8
Total ..	1,82,539	1,369	58,196	2,42,104	12,66,892	19·1

Source :—Directorate of Economics and Statistics, Ministry of Food and Agriculture, Government of India.

STATEMENT VI

Out-turn of timber and fuel of the area under the Control of Forest Departments during 1948–49

Details by States

State	Timber (in thousands cubic feet)	Fuel (in thousands cubic feet)	Total (in thousands cubic feet)	Area under Forest Dept. (sq. mile)	Out-turn in cu. ft. per sq. mile
1	2	3	4	5	6
1. Assam	6,158	8,210	14,368	20,929	686
2. Bihar	3,307	3,693	7,000	2,473	2,831
3. Bombay	17,576	49,871	67,447	15,347	4,395
4. Madhya Pradesh	12,790	48,916	61,706	19,414	3,178
5. Madras	3,603	21,778	25,381	17,504	1,450
6. Orissa	3,556	4,809	8,365	2,874	2,911
7. Punjab	9,807	9,331	19,138	4,873	3,927
8. Uttar Pradesh	11,087	52,945	64 032	10,743	5,960
9. West Bengal	5,347	17,413	22,760	2,680	8,493
10. Hyderabad	1,755	2,736	4,491	9,455	475
11. Jammu & Kashmir	2,481	12,863	15,344	11,058	1,388
12. Madhya Bharat	N.A.	N.A.	N.A.	11,153	N.A.
13. Mysore	1,264	11,959	13,223	4,448	2,973
14. P.E.P.S.U.	76	878	954	332	2,873
15. Rajasthan	N.A.	N.A.	N.A.	12,782	N.A.
16. Saurashtra	280	2,595	2,875	631	4,556
17. Travancore-Cochin	4,747	8,909	13,656	3,065	4,455
18. Ajmer	2	332	334	73	4,575
19. Bhopal	322	268	590	1,209	488
20. Bilaspur	N.A.	N.A.	N.A.	200	N.A.
21. Coorg	1,041	578	1,619	829	1,953
22. Delhi	..	..	..	..	..
23. Himachal Pradesh	1,000	400	1,400	2,999	467
24. Kutch	..	N.A.	N.A.	169	N.A.
25. Manipur	243	867	1,110	2,250	493
26. Tripura	343	130	473	3,610	131
27. Vindhya Pradesh	4,456	2,819	7,275	7,968	913
28. The Andaman & Nicobar Islands..	2,423	49	2,472	2,189	1,129
Total	93,664*	2,62,349*	3,56,013*	1,71,257	2,423*

* Excluding Madhya Bharat, Rajasthan, Bilaspur and Kutch.

Source ;—Directorate of Economics and Statistics, Ministry of Food and Agriculture, Government of India.

STATEMENT VII

Per Capita out-turn of timber and fuel of the area under the control of Forest Departments during 1948–49

Details by States

State	Population according to 1951 census (in thousands)	Out-turn of timber and fuel (in thousand cu. ft.)	Per Capita out-turn in cu. ft.
1	2	3	4
1. Assam	9,690	14,368	1·5
2. Bihar	40,219	7,000	0·2
3. Bombay	35,944	67,447	1·9
4. Madhya Pradesh	21,328	61,706	2·9
5. Madras	56,952	25,381	0·4
6. Orissa	14,644	8,365	0·6
7. Punjab	12,639	19,138	1·5
8. Uttar Pradesh	63,254	64,032	1·0
9. West Bengal	24,787	22,760	0·9
10. Hyderabad	18,653	4,491	0·2
11. Jammu and Kashmir	4,370	15,344	3·5
12. Madhya Bharat	7,942	N.A.	N.A.
13. Mysore	9,072	13,223	1·5
14. P.E.P.S.U.	3,469	954	0·3
15. Rajasthan	15,298	N.A.	N.A.
16. Saurashtra	4,136	2,875	0·7
17. Travancore-Cochin	9,265	13,656	1·5
18. Ajmer	693	334	0·5
19. Bhopal	838	590	0·7
20. Bilaspur	128	N.A.	N.A.
21. Coorg	229	1,619	7·1
22. Delhi	1,744	..	..
23. Himachal Pradesh	989	1,400	1·4
24. Kutch	568	N.A.	N.A.
25. Manipur	579	1,110	1·9
26. Tripura	650	473	0·7
27. Vindhya Pradesh	3,577	7,275	2·0
28. The Andaman and Nicobar Islands ..	31	2,472	79·7
Total	3,61,688	3,56,013*	1·1*

* Excluding Madhya Bharat, Rajasthan, Bilaspur and Kutch.

Source :—Directorate of Economics and Statistics, Ministry of Food and Agriculture, Government of India.

STATEMENT VIII

National income of the Indian Union by Industrial origin 1948–49

Item	Net output (Rs. 100 crores)
(1)	(2)
AGRICULTURE	
1. Agriculture, animal husbandry and ancillary activities[1]	40·7
2. *Forestry	0·6
3. Fishery	0·2
4. Total of agriculture	41·5
MINING, MANUFACTURING AND HAND-TRADES	
5. Mining	0·6
6. Factory establishments	5·8
7. Small enterprises	8·6
8. Total of mining, manufacturing and hand-trades	15·0
COMMERCE, TRANSPORT AND COMMUNICATION	
9. Communications (post, telegraph and telephone)	0·3
10. Railways	2·0
11. Organized banking and insurance	0·5
12. Other commerce and transport[2]	14·2
13. Total of commerce, transport and communications	17·0
OTHER SERVICES	
14. Professions and liberal arts	3·2
15. Government services (administration)	4·6
16. Domestic service	1·5
17. House property	4·5
18. Total of other services	13·8
19. Net domestic product at factor cost	87·3
20. Net earned income from abroad	(–) 0·2
21. Net national output at factor cost = national income	87·1
Net national income per capita (in rupees)	255

[1]These include processing, marketing and ancillary activities performed by the cultivator in respect of his own produce.

[2]Include services of indigenous money-lenders.

Source :—First report of the National Income Committee, April, 1951. Department of Economic Affairs, Ministry of Finance, Government of India.

STATEMENT IX
Importance of Means of Transportation

(i) Route Mileage of Railways[1] (open for traffic at the end of the year)			
	1947–48	1948–49	1949–50
(*a*) Broad Gauge—Miles	15,639	15,694	15,693
(*b*) Meter Gauge—Miles	15,008	14,768	14,950
(*c*) Narrow Gauge—Miles	3,338	3,399	3,379
Total Route Mileage ..	33,985	33,861	34,022
(ii) Mileage of Extra-Municipal Roads[2] (Indian Provinces)			
	As on 31–3–47		As on 31 3–48
(*a*) Surfaced Macadam	64,646	..	65,873
(*b*) Unsurfaced (unmetalled)	1,06,455	..	1,19,455
Total Road Mileage maintained by public authorities	1,71,101	..	1,85,328
(iii) Length of Canal open for Navigation			
	1947–49	1948–49	1949–50
Miles	16,694	17,130	N.A.

[1]Relates to Indian Union only.
[2]Figures are provisional and relate to former provinces as they stood immediately after partition.
Source :—Central Statistical Organization, Cabinet Secretariat.

STATEMENT X
Annual production of Paper, Plywood and Matches

	Units	Years			
		1948	1949	1950	1951*
1. *Paper*					
(*a*) Printing and writing	Tons	50,376	59,484	70,152	78,661
(*b*) Wrappings	,,	17,388	12,876	14,616	25,113
(*c*) Special varieties	,,	12,912	11,904	5,196	3,222
(*d*) Board	,,	17,232	18,936	18,948	24,189
Total	,,	97,908	1,03,200	1,08,912	1,31,185
Installed capacity (Total) ..	,,	1,05,000	1,10,004	1,13,424	1,35,295
2. *Plywood*					
(*a*) Tea-chests	Lac sq. ft.	451·2	384·0	414·0	601·7
(*b*) Commercial	,,	86·4	92·4	88·8	101·5
Total	,,	537·6	476·4	502·8	703·2
Installed capacity (Total) ..	,,	630·0	999·6	1,251·6	1,444·4
3. *Matches*	Thousand cases†	532·8	526·8	523·2	578·4
Installed capacity ..	,,	800·4	800·4	800·4	768·8

* Figures except those of installed capacity are subject to slight revision as December, 1951 figures are incomplete.
† 50 gross boxes of 60 sticks each.
Source :—Directorate of Industrial Statistics, Ministry of Commerce and Industry.

INDIGENOUS CELLULOSIC RAW MATERIALS FOR THE PRODUCTION OF PULP, PAPER AND BOARD

PART XI.—CHEMICAL PULPS FROM *ANDROPOGON CONTORTUS*, LINN. (*KUSAL* GRASS)

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SUMMARY

Laboratory experiments on the preparation of chemical pulps by the soda and sulphate processes from *Andropogon contortus*, Linn., syn. *Heteropogon contortus* (Linn.) Roem. and Schult. (*kusal* grass) are described. Higher quantities of chemicals are required for the production of pulps from this grass than from sabai grass (*Eulaliopsis binata*). The pulps from this grass are short-fibred and, therefore, may require to be used in admixture with a long-fibred pulp such as sabai grass or bamboo pulp for the production of writing and printing papers. The economic utilization of this grass for the manufacture of paper will depend upon the price at which it will be available at factory site.

INTRODUCTION

Andropogon contortus, Linn., syn. *Heteropogon contortus* (Linn.) Roem. and Schult. (*kusal* grass) belongs to the family Gramineæ. It is a perennial grass with densely tufted culms, erect or geniculately ascending, more or less compressed below. The culms are up to 5 feet long, glabrous, smooth, quite simple or more often branched. The leaves are narrow up to 2 feet long, 0·1–0·3 inch wide, flat and taper to a point. The sheaths are compressed, keeled, quite glabrous or with a few tubercle-based hairs towards the mouth[1]. The grass flowers between August and January[2].

Kusal grass is known as "spear grass". It is found chiefly in dry areas. It grows on a wide variety of soils and often becomes dominant on poor rocky inhospitable land. It is found throughout India and also in Burma. It ascends the Himalayas to a height of about 5,000 feet. This grass occurs in Punjab, Uttar Pradesh, Bengal, Madhya Pradesh, Bombay and Madras. At the instance of the Chief Conservator of Forests, Madhya Pradesh, an investigation was undertaken in this Institute on the production of chemical pulps from this grass. The results are recorded in this bulletin as an interim report.

THE RAW MATERIAL

The grass for this investigation was supplied by the Divisional Forest Officer, Nagpur-Wardha Division, at the instance of the Chief Conservator of Forests, Madhya Pradesh. The supplies (200 lb.) consisted of stems, 3–4 feet long, with leaves and flowers. The stems were light greenish-yellow and the leaves light reddish-brown. The moisture content of the grass as received was 8%. The stems with leaves and flowers were chopped on the factory grass chopper into pieces of about 1 inch length and used for the digestions after sieving on a 20-mesh sieve to remove the fines. Some preliminary experiments were carried out on the grass which was crushed between the rollers of the factory crusher before chopping.

PROXIMATE ANALYSIS

Some chopped grass was converted into dust and the portion passing through 60-mesh and retained on 80-mesh was used for the estimation of all the constituents by TAPPI methods. The results are recorded in Table I.

TABLE I

Proximate analysis of Andropogon contortus

	% expressed on the oven-dry basis except moisture
1. Moisture	6·62
2. Ash	7·50
3. Cold water solubility	10·92
4. Hot water solubility	15·46
5. 1% NaOH solubility	38·30
6. 10% KOH solubility	55·60
7. Ether solubility	1·57
8. Alcohol-benzene solubility..	4·35
9. Pentosans	16·92
10. Lignin	27·30
11. Cellulose (Cross and Bevan)	52·10

It is seen from these results that this grass contains a high proportion of mineral matter and hemicelluloses. The cellulose content of the grass is sufficiently high to warrant its utilization for the manufacture of paper.

FIBRE DIMENSIONS

The measurements of the length and diameter of fibres of chemical pulps prepared from this species by the soda process using 20% caustic soda (on the oven-dry basis of the raw material) at 153°C. for 6 hours were carried out by the usual procedures followed in this laboratory. A material-liquor ratio of 1 : 6 was used for the digestion. The average fibre length of the pulp was 1·10 mm., the minimum and maximum values being 0·42 mm. and 3·08 mm. respectively. The average fibre diameter was found to be 0·0097 mm. The minimum value found for the fibre diameter was 0·0065 mm. and the maximum value 0·0190 mm. The ratio of the average fibre length to diameter was 113 : 1. It is clear from these results that the pulp is short-fibred.

PRODUCTION OF PULP

The digestion of the chopped grass was carried out under various conditions by the soda and sulphate processes. In the sulphate process caustic soda and sodium sulphide were used in the ratio of 2 : 1. Since the preliminary experiments showed that a volume of cooking liquor five times the weight of the material (on the oven-dry basis) was not sufficient to cover the grass properly, a material-liquor ratio of 1 : 6 was used in all the digestions reported in

Tables II and III. The digestions were carried out in a cast iron autoclave and 200 g. of the chopped grass were used in each digestion. After the digestion was completed, the pulp was washed on a 60 mesh sieve and bleached with a solution of bleaching powder in two stages. In the first stage of the bleaching, about 75% of the total requirement of the bleaching powder was used. The partially bleached pulp was washed with water after the bleaching agent was exhausted and treated with 2% caustic soda at 70°C. for 1 hour. After washing, the pulp was bleached with the rest of the bleaching powder. In all these stages, the pulp was used at 5% consistency. The bleaching was carried out at 8–9 pH in both the stages. Since the intermediate alkali treatment has been found to give a lower yield of bleached pulp in the case of some grasses tested in this laboratory, a portion of the pulp after the first bleach was subjected to the second bleaching treatment without the intermediate alkali treatment. Sufficient bleaching powder was used to make the pulp satisfactorily white.

The brightness of standard pulp sheets made from the various pulps was measured by means of the Photoelectric Reflection Meter Model 610 (Photovolt Corporation, U.S.A.) and the results were expressed on the basis of the brightness of magnesium oxide equal to 100. The conditions of the digestions, the yields of the unbleached and bleached pulps, the bleach consumption and the strength properties and brightness of standard pulp sheets are recorded in Table II in the case of the soda process and in Table III in the case of the sulphate process.

DISCUSSION

The results recorded in Table II show that this grass required higher quantities of chemicals for digestion and bleaching than sabai grass to yield satisfactory pulps of good whiteness. Experiments carried out in this laboratory have shown that easy bleaching pulps of satisfactory strength properties can be obtained from chopped sabai grass if the digestion is carried out with about 17% of caustic soda (on the basis of the oven-dry material) at 153°C. for 5 hours, the bleach consumption being 3·3–4% of standard bleaching powder containing 35% available chlorine. Under the conditions studied, the digestion of the chopped *kusal* grass by the soda process with 20% of caustic soda (on the oven-dry basis of the raw material) at 153°C. for 6 hours, using a material-liquor ratio of 1 : 6 gives well-cooked pulp in satisfactory yields (vide Serial No. 3*a*, Table II). By omitting the intermediate alkali treatment during bleaching a higher yield of bleached pulp with slightly better strength properties is obtained than when this treatment is used. A slightly greater quantity of bleaching powder is required to get pulp of satisfactory whiteness when this intermediate treatment is omitted. From these observations it seems that the alkali treatment removes some hemicelluloses from the pulp.

At the higher temperature of 170°C. used for the digestion, the pulp suffers in yield and strength properties and slightly over-cooked pulp is obtained at this temperature when 22% of caustic soda is used for cooking. Under-cooked pulp containing shives is obtained when the digestion is carried out at 142°C. even with 22% of caustic soda. The temperature of 153°C. is the best for the digestion under the conditions studied. Even at a temperature of 162°C., pulps with slightly lower strength properties than at 153°C. are obtained.

The use of 20% of caustic soda (on the oven-dry basis of the raw material) is quite satisfactory for the digestion of this grass. With 18% of caustic soda, pulps containing shives are obtained and such pulps are not bleached easily to a satisfactory whiteness. When 22% of caustic soda is used for cooking, pulps with slightly lower strength properties are obtained.

TABLE II.—*Soda digestions of Andropogon contortus*

DIGESTION CONDITIONS AND PULP YIELDS

1	2	3	4	5	6	7	8	9
Serial No.	Total alkali as NaOH*	Material: liquor	Digestion temperature	Digestion period	Alkali consumption as NaOH*	Unbleached pulp yield*	Bleach consumption as standard bleaching powder containing 35% available chlorine*	Bleached pulp yield*
	%		°C.	hours	%	%	%	%
1*a*	18	1:6	162	6	17·6	46·6	8·1	34·3
1*b*	18	1:6	162	6	17·6	46·6	8·7	36·0
2*a*	18	1:6	170	6	17·7	45·8	8·0	32·6
2*b*	18	1:6	170	6	17·7	45·8	8·7	34·9
3*a*	20	1:6	153	6	19·5	46·7	8·0	31·7
3*b*	20	1:6	153	6	19·5	46·7	8·5	34·2
4*a*	20	1:6	162	6	19·0	46·1	7·6	31·4
4*b*	20	1:6	162	6	19·0	46·1	7·9	35·8
5	20	1:6	170	6	19·4	44·7	7·0	29·3
6*a*	22	1:6	142	6	18·9	48·0	7·1	34·7
6*b*	22	1:6	142	6	18·9	48·0	8·0	37·0
7	22	1:6	153	6	20·3	45·9	7·3	32·3
8	22	1:6	162	6	20·6	42·7	6·5	31·8
9	22	1:6	170	6	21·1	42·0	6·1	27·2

* The % is expressed on the basis of the raw material (oven-dry).

and strength properties of standard sheets

STRENGTH PROPERTIES OF STANDARD SHEETS CONDITIONED AT 65% R.H. AND 65°F.

10	11	12	13	14	15	16	17	18
Freeness of pulp •	Basis weight	Breaking length	Stretch	Tear factor (Marx-Elmendorf)	Burst factor (Ashcroft)	Folding resistance (Schopper)	Brightness	REMARKS
c.c. (C.S.F.)	g./sq. metre	metres	%			double folds		
266	61·6	7400	5·3	81·2	47·1	290	64	Just cooked. A few shives were present. Pulp was given the intermediate alkali treatment during bleaching.
245	61·6	7650	5·3	88·6	49·1	330	66	The pulp was not given the intermediate alkali treatment.
308	59·6	7650	4·7	83·9	47·2	260	66	Same remarks as in 1*a*.
293	61·6	8550	4·5	92·5	48·7	360	64	The pulp was not given the intermediate alkali treatment.
293	60·8	7900	4·9	74·7	48·6	270	71	Well-cooked pulp. The pulp was given the intermediate alkali treatment.
293	61·6	8210	5·0	82·1	50·2	350	72	The pulp was not given the intermediate alkali treatment.
276	57·0	6820	4·5	76·9	44·0	80	69	Well-cooked pulp. Intermediate alkali treatment given.
297	61·2	7120	4·8	81·7	44·9	200	70	Intermediate alkali treatment not given.
262	62·8	8070	4·7	60·5	42·5	70	73	Well-cooked pulp. Intermediate alkali treatment given.
308	57·0	6850	4·7	70·2	40·7	60	71	Under-cooked pulp. Shives present. Intermediate alkali treatment given.
292	60·4	7950	5·0	75·7	44·2	140	71	Intermediate alkali treatment not given.
293	62·8	7310	3·8	80·0	43·6	110	75	Well-cooked pulp. Intermediate alkali treatment given.
292	64·0	7000	4·5	67·2	40·6	50	75	Well-cooked pulp. Intermediate alkali treatment given.
272	61·6	7040	4·3	58·9	32·2	20	72	Slightly over-cooked pulp. Intermediate alkali treatment given.

TABLE III.—*Sulphate digestions of Andropogon contortus*

DIGESTION CONDITIONS AND PULP YIELDS

1	2	3	4	5	6	7	8	9
Serial No.	Total chemicals* (NaOH : Na_2S=2 : 1)	Material : liquor	Digestion temperature	Digestion period	Consumption of chemicals*	Unbleached pulp yield*	Bleach consumption as standard bleaching powder containing 35% available chlorine*	Bleached pulp yield* •
	%		°C.	hours	%	%	%	%
1*a*	20	1:6	153	6	19·6	50·4	7·1	34·3
1*b*	20	1:6	153	6	19·6	50·4	7·7	38·3
2*a*	20	1:6	162	6	19·4	47·3	7·0	32·1
2*b*	20	1:6	162	6	19·4	47·3	7·6	36·4
3*a*	20	1:6	170	6	18·5	47·4	6·9	33·3
3*b*	20	1:6	170	6	18·5	47·4	7·0	36·1
4*a*	22	1:6	153	6	21·4	48·7	6·0	34·4
4*b*	22	1:6	153	6	21·4	48·7	6·9	35·9
5*a*	22	1:6	162	6	20·6	47·6	6·1	33·1
5*b*	22	1:6	162	6	20·6	47·6	7·0	35·8
6*a*	22	1:6	170	6	21·3	43·6	6·7	27·2
6*b*	22	1:6	170	6	21·3	43·6	7·0	28·3

* The % is expressed on the basis of the raw material (oven-dry).

and strength properties of standard sheets

STRENGTH PROPERTIES OF STANDARD SHEETS CONDITIONED AT 65% R.H. AND 65°F.

10	11	12	13	14	15	16	17	18
Freeness of pulp *	Basis weight	Breaking length	Stretch	Tear factor (Marx-Elmendorf)	Burst factor (Ashcroft)	Folding resistance (Schopper)	Brightness	REMARKS
c.c. (C.S.F.)	g./sq. metre	metres	%			double folds		
310	60·0	8420	4·4	88·0	50·5	380	69	Just cooked. A few shives were present. Pulp was given the intermediate alkali treatment during bleaching.
315	60·2	9000	5·1	98·5	53·4	290	69	The pulp was not given the intermediate alkali treatment.
284	60·0	7560	4·0	81·7	44·5	220	71	Well-cooked pulp. The pulp was given the intermediate alkali treatment.
284	62·8	8920	4·7	92·4	50·4	410	69	The pulp was not given the intermediate alkali treatment.
298	60·8	7350	4·3	90·5	47·4	240	69	Same remarks as in 2*a*.
308	60·8	7570	4·2	90·5	47·4	250	64	The pulp was not given the intermediate alkali treatment.
304	61·2	6860	3·3	93·1	44·3	220	72	Well-cooked pulp. Intermediate alkali treatment given.
314	60·8	7950	4·0	94·6	47·6	290	67	The pulp was not given the intermediate alkali treatment.
330	60·0	7110	3·9	93·3	44·6	210	70	Well-cooked pulp. Intermediate alkali treatment given.
320	58·8	7710	4·1	102·5	47·9	270	65	The pulp was not given the intermediate alkali treatment.
310	60·4	6960	4·0	92·7	46·8	230	65	Well-cooked pulp. Pulp was given the intermediate alkali treatment during bleaching.
320	61·0	7320	4·4	97·0	49·5	310	58	The pulp was not given the intermediate alkali treatment.

The results recorded in Table III show that well-cooked pulp of satisfactory strength properties can also be obtained by the sulphate process. The digestion of the chopped grass with 20% of chemicals at 162°C. for 6 hours gives well-cooked pulp. The yield of the pulp is satisfactory. A higher yield of bleached pulp is obtained if the intermediate alkali treatment is omitted in the bleaching process; the strength properties of the bleached pulps are also better in that case. If the higher temperature of 170°C. is used for cooking, pulps with lower strength properties are obtained. When 22% of chemicals is used for the digestion, the pulp obtained by cooking at a higher temperature of 170°C. requires a longer time for bleaching and the bleached pulp retains a yellowish tinge.

On comparing the sulphate pulps with the soda pulps (Tables III and II), it is seen that bleached pulps in higher yields and with higher strength properties are obtained by the sulphate process. The bleach consumption is lower in the case of the sulphate process. The chemicals for the digestion and bleaching are, however, still required in larger quantities for *kusal* grass than for sabai grass. On the whole, the sulphate process seems to be preferable for digesting *kusal* grass for the production of chemical pulps for writing and printing papers. Since the pulps are short-fibred, *kusal* grass pulps may require to be admixed with a long-fibred pulp such as that from sabai grass or bamboo.

CONCLUSIONS

1. Chemical pulps of satisfactory strength properties can be prepared from *kusal* grass by the soda and sulphate processes. The sulphate process is preferable to the soda process since it gives pulps in higher yields and with higher strength properties. The bleach consumption is also lower.

2. If the intermediate alkali treatment is omitted in the bleaching process, the yield and the strength properties of the bleached pulp are improved.

3. Since *kusal* grass pulps are short-fibred, they may require to be admixed with a long-fibred pulp such as that of sabai grass or bamboo for the manufacture of writing and printing papers.

4. Larger quantities of chemicals are required for the production of chemical pulps from *kusal* grass than from sabai grass and hence the economic utilization of *kusal* grass for the paper industry will depend upon its price at the mill site.

Thanks are given to the Chief Conservator of Forests, Madhya Pradesh and the Divisional Forest Officer, Nagpur-Wardha Division, for the supply of *kusal* grass for this investigation.

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GENERAL FORMULÆ FOR MEASUREMENT OF HEIGHTS OF TREES

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Introduction.—The formulæ usually adopted for measuring heights of trees with clinometers do not take into consideration the lean of the trees. Quite appreciable errors are introduced by ignoring the lean. It was felt that formulæ should be evolved which would also take into consideration the lean of the tree, so that heights of leaning trees could be ascertained accurately.

Derivation of the formulæ.—Such formulæ may be derived by adopting the well known trigonometrical relation $\frac{a}{\text{Sin A}} = \frac{b}{\text{Sin B}} = \frac{c}{\text{Sin C}}$, where a, b, c are the three sides of the triangle and A, B and C the angles opposite to them. The formulæ suited to the different cases met with under forest conditions will be found derived below :—

CASE I(*a*).

The following is the case of the observer standing between the top and the bottom of the tree, i.e., the horizontal ray taken from his eye cuts the tree. The observer stands in the same plane as the lean, the lean being away from the observer, vide Fig. (1).

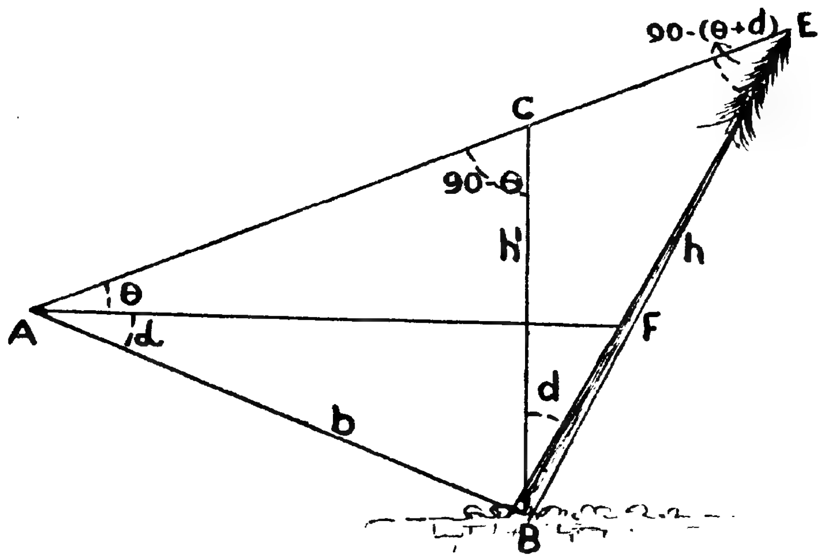

FIG. 1.

In this figure BE is the leaning tree of height, say h. A is the observer's eye, and AF is the horizontal ray from it meeting the tree at F. Let AB be equal to b and let $\angle$FAE, the angle of elevation be called θ. Similarly $\angle$FAB, the angle of depression be called a. BC is the vertical line drawn from the foot of the tree B meeting AE, the ray to the top of tree, at C.

If the usual formula, height of tree = b cos a (tan θ + tan a) is applied the value obtained will be equal to BC or h', whereas the real height of the tree will be equal to BE or h.

Let the angle of lean of the tree be, d

Now in Fig. 1

$$\angle ACB = \angle CBE + \angle CEB$$

and $\angle ACB = 90^\circ - \theta$ and $\angle CBE = d$

$$\therefore \angle CEB = 90^\circ - \theta - d = 90^\circ - (\theta + d)$$

In the $\triangle$ AEB

$$\frac{b}{\text{Sin AEB}} = \frac{h}{\text{Sin}(\theta + a)}$$

As $\angle AEB$ is the same as $\angle CEB$ which is equal to $90^\circ - (\theta + d)$

$$\frac{b}{\text{Sin}[90 - (\theta + d)]} = \frac{h}{\text{Sin}(\theta + a)}$$

$$\therefore h = \frac{b \text{ Sin}(\theta + a)}{\text{Sin}[90 - (\theta + d)]} = \frac{b \text{ Sin}(\theta + a)}{\text{Cos}(\theta + d)} \quad \ldots \quad (1)$$

Relation between the real height and the apparent height of the tree.—The relation between h the real height of the tree and h′ the apparent height is given below :—

In Fig. 1 in the $\triangle$ CBE

$$\frac{h}{\text{Sin BCE}} = \frac{h'}{\text{Sin CEB}}$$

i.e., $$\frac{h}{\text{Sin}(90 + \theta)} = \frac{h'}{\text{Sin}[90 - (\theta + d)]}$$

As $\text{Sin}(90 + \theta) = \text{Cos}\,\theta$ and $\text{Sin}[90 - (\theta + d)] = \text{Cos}(\theta + d)$; substituting,

$$\frac{h}{\text{Cos}\,\theta} = \frac{h'}{\text{Cos}(\theta + d)}$$

$$\therefore h = \frac{h' \text{ Cos}\,\theta}{\text{Cos}(\theta + d)} \quad \ldots \quad (2)$$

When $d = 0$, i.e., when the tree has no lean,

$$h = h'$$

Again in equation (1)

$$h = \frac{b \text{ Sin}(\theta + a)}{\text{Cos}(\theta + d)}$$

when $d = 0$, the equation becomes

$$h = \frac{b \text{ Sin}(\theta + a)}{\text{Cos}\,\theta} = \frac{b(\text{Sin}\,\theta \text{ Cos}\,a + \text{Cos}\,\theta \text{ Sin}\,a)}{\text{Cos}\,\theta}$$

$$= b \text{ Cos}\,a \left[\frac{\text{Sin}\,\theta}{\text{Cos}\,\theta} + \frac{\text{Cos}\,\theta}{\text{Cos}\,\theta} \times \frac{\text{Sin}\,a}{\text{Cos}\,a}\right]$$

$$= b \text{ Cos}\,a [\tan\theta + \tan a] \quad \ldots \quad (3)$$

This is the usual formula found in text books for calculating heights of trees covered by Case (I) and with no lean. This has now been shown, to be only a particular case of the general equation (1) namely, $h = \frac{b \text{ Sin}(\theta + a)}{\text{Cos}(\theta + d)}$, where h is the real height of the tree, b is the distance from the observer's eye to the foot of the tree and θ, a and d are the angles of elevation, depression and lean respectively.

Modification of the formula to suit the other cases.

CASE I(*b*).—When the tree leans towards the observer, vide Fig. (2).

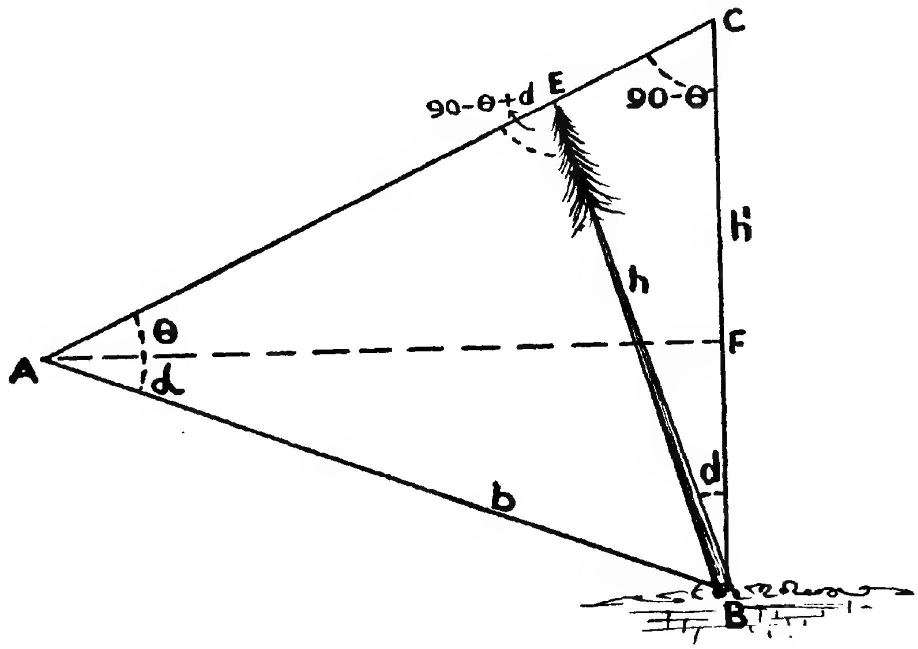

FIG. 2.

The same symbols as used in Fig. (1) are used here also.

In Fig. (2) in $\triangle$ AEB

$$\frac{\text{b}}{\text{Sin AEB}} = \frac{\text{h}}{\text{Sin}\ (\theta + a)}$$

$\angle$AEB $= \angle$ECB $+ \angle$EBC internal opposite angles of $\triangle$ ECB.

$$= 90 - \theta + \text{d}$$

$$= 90 - (\theta - \text{d}).$$

Substituting in (*a*) above,

$$\frac{\text{b}}{\text{Sin}\ [\,90 - (\theta - \text{d})\,]} = \frac{\text{h}}{\text{Sin}\ (\theta + a)}$$

and as Sin $(90 - \overline{\theta - \text{d}}) = \text{Cos}\ (\theta - \text{d})$

$$\frac{\text{h}}{\text{Sin}\ (\theta + a)} = \frac{\text{b}}{\text{Cos}\ (\theta - \text{d})}$$

$$\therefore \text{h} = \frac{\text{b Sin}\ (\theta + a)}{\text{Cos}\ (\theta - \text{d})} \qquad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (4)$$

CASE II.

When the tree is below the observer who is standing in the same plane as the direction of the lean two cases, of tree leaning away from him and of tree leaning towards him, will arise, vide Figs. 3 and 4. The formulæ for these two cases are derived below :—

(*a*) Tree leaning away from the observer, vide Fig. (3).

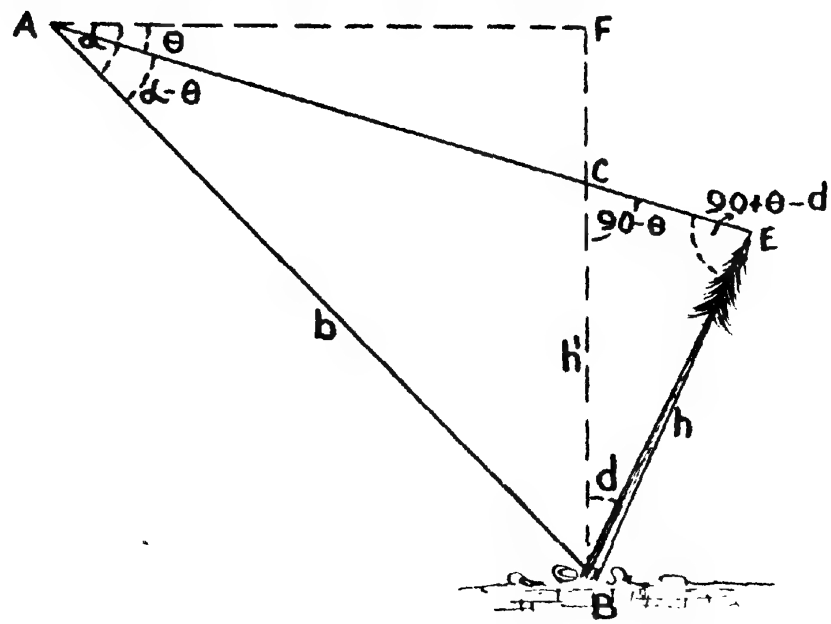

FIG. 3.

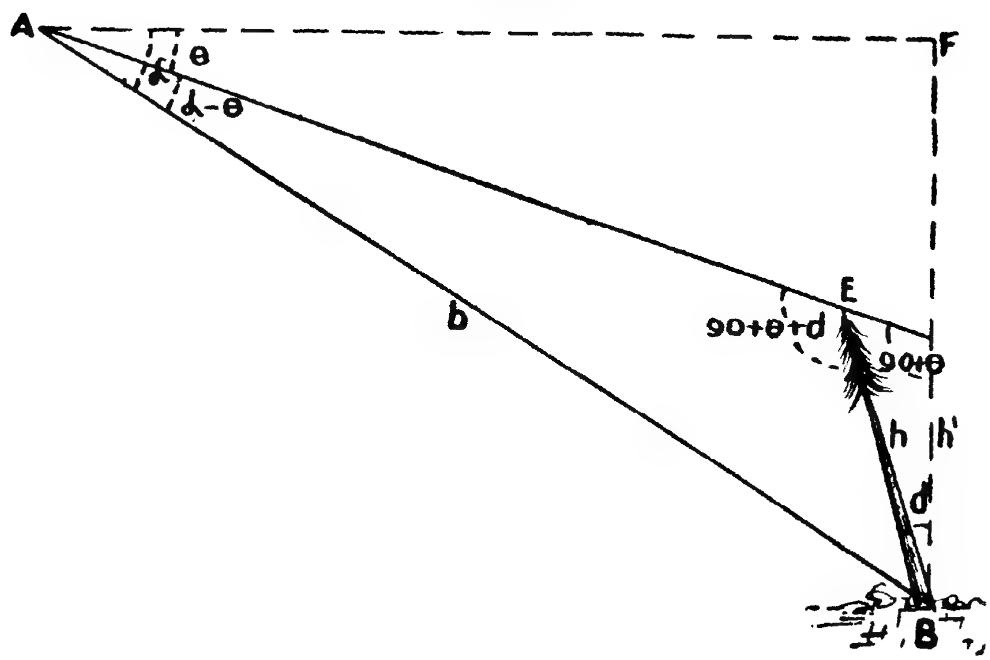

FIG. 4.

In Fig. (3) in $\triangle$ AEB

$$\frac{h}{\text{Sin}(\alpha-\theta)}=\frac{b}{\text{Sin}[90+(\theta-d)]},$$ where h, b, θ, α and d have the same meanings as in the previous cases.

As $\text{Sin}(90+\overline{\theta-d})=\text{Cos}(\theta-d)$

$$\frac{h}{\text{Sin}(\alpha-\theta)}=\frac{b}{\text{Cos}(\theta-d)}$$

$$\therefore\ h=\frac{b\ \text{Sin}(\alpha-\theta)}{\text{Cos}(\theta-d)} \quad \ldots \quad (5)$$

(*b*) Tree leaning towards the observer :—

In Fig. (4) in the $\triangle$ AEB

$$\frac{h}{\text{Sin}(\alpha-\theta)}=\frac{b}{\text{Sin}[90+(\theta+d)]}$$

As $\text{Sin}[90+(\theta+d)]$ is the same as $\text{Cos}(\theta+d)$

$$\frac{h}{\text{Sin}(\alpha-\theta)}=\frac{b}{\text{Cos}(\theta+d)}$$

$$\therefore\ h=\frac{b\ \text{Sin}(\alpha-\theta)}{\text{Cos}(\theta+d)} \quad \ldots \quad (6)$$

CASE III.

When the tree is above the observer, two cases of the tree leaning away from the observer and towards him will arise as shown in Figs. 5 and 6 respectively. The formulæ relating to these two cases are derived below, adopting the same method as in previous cases.

CASE III(*a*).

When the tree is leaning away from the observer, vide Fig. (5).

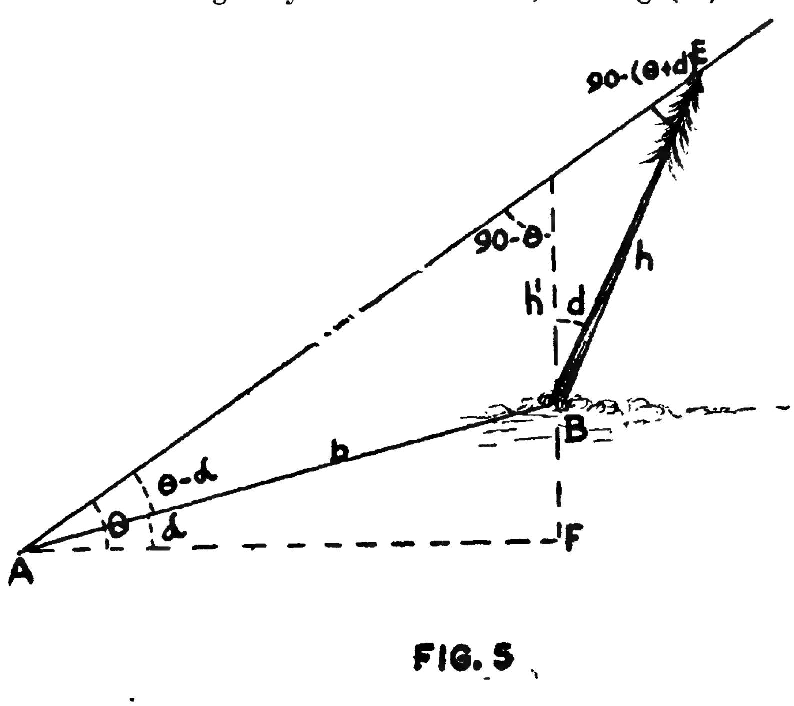

FIG. 5

In Fig. (5) in the $\triangle$ AEB

$$\frac{h}{\sin(\theta-\alpha)}=\frac{b}{\sin[90-(\theta+d)]}=\frac{b}{\cos(\theta+d)}$$

$$\therefore\ h=\frac{b\sin(\theta-\alpha)}{\cos(\theta+d)} \quad \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \quad (7)$$

CASE III(*b*).

When the tree is leaning towards the observer, vide Fig. (6).

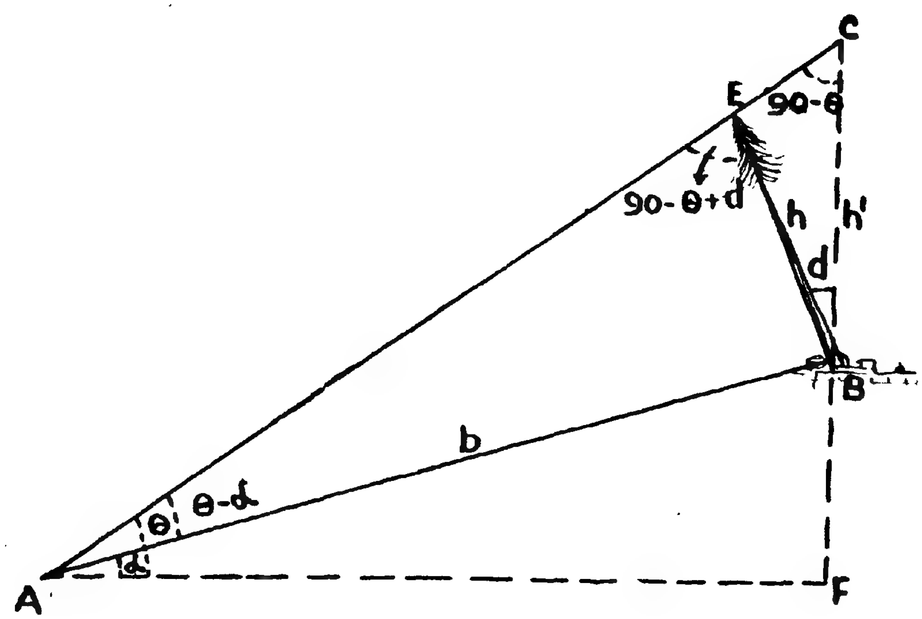

FIG. 6.

In Fig. (6) in the $\triangle$ AEB

$$\frac{h}{\sin(\theta-\alpha)}=\frac{b}{\sin[90-(\theta-d)]}=\frac{b}{\cos(\theta-d)}$$

$$\therefore\ h=\frac{b\sin(\theta-\alpha)}{\cos(\theta-d)} \quad \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \quad (8)$$

Tabular statement of the formulæ.—The following tabular statement will give the formulæ derived for all the cases usually met with.

Position of the observer	Position of tree	
	Leaning away from observer	Leaning towards observer
I. Observer between top and bottom of tree.	$h = \dfrac{b \text{ Sin } (\theta + a)}{\text{Cos } (\theta + d)}$	$h = \dfrac{b \text{ Sin } (\theta + a)}{\text{Cos } (\theta - d)}$
II. Tree below observer ..	$h = \dfrac{b \text{ Sin } (a - \theta)}{\text{Cos } (\theta - d)}$	$h = \dfrac{b \text{ Sin } (a - \theta)}{\text{Cos } (\theta + d)}$
III. Tree above observer ..	$h = \dfrac{b \text{ Sin } (\theta - a)}{\text{Cos } (\theta + d)}$	$h = \dfrac{b \text{ Sin } (\theta - a)}{\text{Cos } (\theta - d)}$

In the above formulæ

h, is the real height of the tree,

b, is the length from the observer's eye to the base of the tree,

θ, is the angle from the horizontal to the top of the tree,

a, is the angle from the horizontal to the base of the tree,

and d, is the angle of lean of the tree from the normal.

The possibility of deriving a general formula to cover all the above cases utilizing the positive and negative values of Sine and Cosine in the different quadrants was considered, but this was not possible on account of the complication introduced by the angle of lean of the tree. In any event a complicated general formula involving in its use a more intimate knowledge of trigonometrical and geometrical principles is of doubtful utility to the average forest subordinate.

Table showing the relation between h′ *the apparent height and* h *the real height.*—In equation (2) given earlier the relation between h′ the apparent height and h the real height has been given as

$$h = h' \frac{\text{Cos } \theta}{\text{Cos } (\theta + d)}$$

when the tree is inclined away from the observer, whose position is covered by Case I(a), i.e., he stands between top and the bottom of tree.

Assuming h′ to be 100 feet and θ to be 45°, the value of h for different angles of lean of the tree is given below :—

d	h	d	h
	feet		*feet*
1°	101·8	6°	112·4
2°	103·7	7°	114·9
3°	105·7	8°	117·5
4°	107·8	9°	120·3
5°	110·0	10°	123·3

This table will give an idea of the error introduced by ignoring the lean of the tree.

General precautions.—To get reasonably accurate values for the different angles to be measured, the clinometer is usually rested on a staff when taking the readings. The ray to

the bottom of the tree is always taken to the top of a similar staff placed on the ground and touching the tree. By adding the length of the staff to the ascertained height, the correct height of the tree is obtained. The distance is measured from the top of the observer's staff to the top of the staff placed against the tree. The observer should invariably stand in the plane of lean of the tree and at a distance approximately equal to the height of the tree. For using these formulæ, the lean of the trees concerned have to be determined. The mode of determining this is described in the next paragraph.

Measurement of the lean of the tree.—For measuring the lean of the tree a plumb bob with a device for reading the angles directly is necessary. A simple instrument which was used for this purpose is described below, vide Figs. 7 and 8.

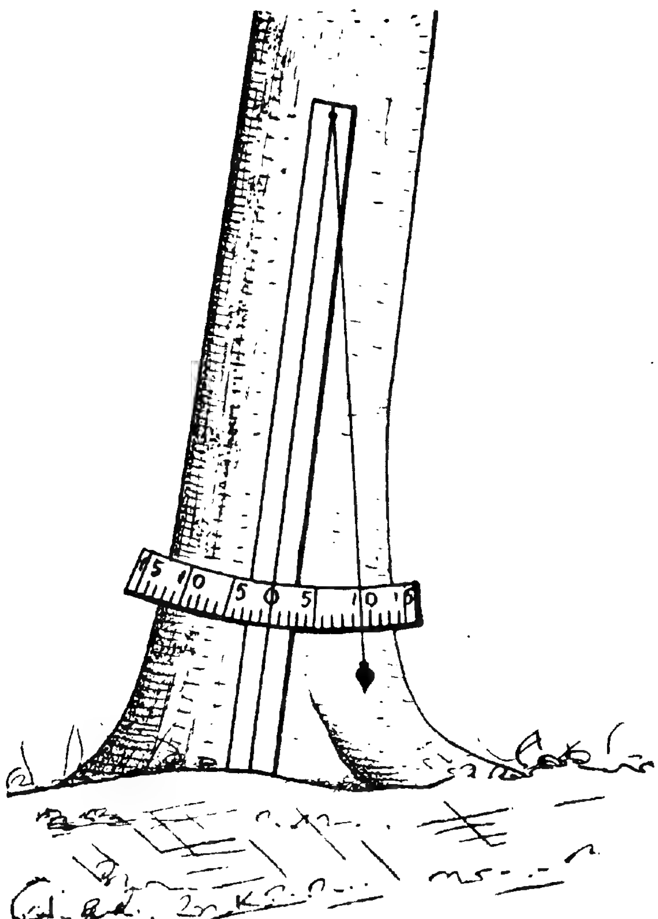

FIG. 7.

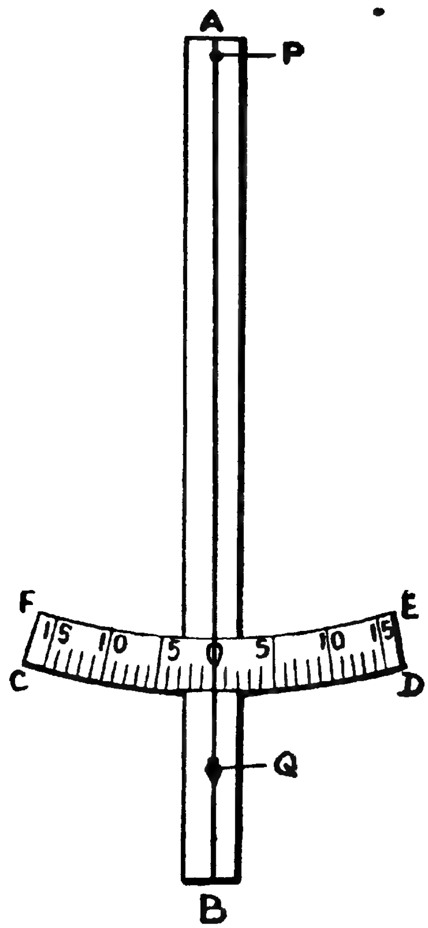

FIG. 8.

AB is a smooth batten rectangular in section about 5 to 6 feet in length. A centre line is drawn on the broad face. Near one end at P, a hole is bored right through. Through this hole, a thin string with a bob Q is suspended, when measurements have to be taken. About 18 inches from B a cross piece CDEF is fixed flush to the batten. In this cross piece FE is the arc of the circle with PF = PE as radius. Similarly CD is the arc of the circle with PC = PD as radius. The centre line of the batten AB passes through this cross batten and

is marked zero. On either side of this zero mark, graduations are made to show the degrees 1, 2, 3, 4, 5 and so on. Such graduations are not difficult to make as the length of the arc along CD or FE subtending one degree at P, the centre of the circle, can easily be calculated. In the next instrument which will be manufactured, the cross batten will be straight and fixed at right angles to batten AB. Also the arrangement at P for fixing the string will be improved so that friction may be reduced. The graduations in this case can be made with the help of a table of tangents and marked all along CD. When the batten AB is held vertically the string of the bob will pass over 0° mark of the scale. When it is tilted by 5°, the string will pass over the 5° mark on the cross piece.

This simple apparatus is placed vertically against the tree to be measured, and AB is so aligned that it is parallel to the axis of the lean of the tree as shown in Fig. 7. For this purpose one should stand at right angles to the plane of lean of the tree. The reading on the cross scale over which the string of the bob passes represents the angle of lean of the tree. Care should be taken to see that the string with the bob *just* moves free of the cross scale. With a little bit of practice fairly accurate values of the lean of the tree can be obtained, even with this apparatus.

Field Tests.—Field tests were carried out with trees having lean. The apparatus described in the previous paragraph was used for measuring the lean. Eleven trees were measured and for each tree two readings were taken, one when it was leaning away from the observer and the other when it was leaning towards him. The following table shows the species, the leans of the trees, their heights calculated by the above formulæ and their actual heights measured with tape and staff.

Species	Angle of lean of tree	Height calculated as per the new formulæ		Actual height measured with tape and staff
		With Tree leaning towards the measurer	With Tree leaning away from the measurer	
		feet	*feet*	*feet*
1. *D. sissoo* ..	12°	46·7	45·9	46·0
2. *Do.* ..	7°	41·8	40·8	41·0
3. *Do.* ..	11°	51·1	48·9	50·0
4. *Do.* ..	12°	63·7	62·8	63·0
5. *Eucalyptus* ..	11°	53·4	53·9	55·5
6. *Do.* ..	2°–45′	80·0	81·7	80·8
7. *P. longifolia* ..	3°–15′	54·6	55·3	55·2
8. *Do.* ..	3°–30′	55·2	56·4	56·0
9. *Do.* ..	3°–0′	52·5	52·6	51·8
10. *T. myriocarpa* ..	12°–0′	78·5	80·6	79·9
11. *Grevillea robusta* ..	6°–50′	66·2	67·1	67·0

From the above tables, it will be clear that even with a simple device like the one used for measuring the lean of trees it will be possible to get fairly accurate heights of trees, applying the formulæ mentioned in this paper.

NOTES ON THE UTILIZATION AND SILVICULTURE OF THE TIMBERS USED IN WOOD BASED INDUSTRIES OF INDIA

(*Continued from* Indian Forester, *June 1952, page 288*)

III. PAPER INDUSTRY

1. LOCATION OF INDUSTRY : PRODUCTION AND CONSUMPTION OF PAPER

The paper industry, in addition to being a key industry in the nation's economy, is one of the important consumers of forest products. There were 16 paper mills in India towards the close of 1950. Four of these are situated in Bengal, three in Bombay, two in Uttar Pradesh and one each in Bihar, Orissa, Madras, Hyderabad, Mysore, Travancore and Punjab. Three more new mills—two in Madhya Pradesh and one in Mysore were under construction. The above mills produced 1,10,000* tons of writing and printing papers, which met the major portion of the country's requirements in this direction. India consumed about 60,000 tons of newsprint during the year, the whole of which had to be imported as there are no mills for producing this category of paper. India also imported 12,000 tons of printing and wrapping papers to fill the gap between internal production and consumption.

2. ANTICIPATED CONSUMPTION IN THE FUTURE

According to the report of the "Panel on Paper Pulp and Board and Chemical Cotton Industries" appointed by the Government of India after the war, our anticipated consumption of paper in 1956 will be as follows :—

Writing and Printing papers	2,00,000 tons
Cheap wrapping paper and kraft paper	1,00,000 ,,
Newsprint	1,00,000 ,,
Total ..	4,00,000 tons

Considering that our per capita consumpiton of paper is only a very small fraction of that of the more advanced countries of the world, our consumption is bound to rise sharply as the country develops. It will not be an over estimate to place our anticipated total requirements in 1961 at 6 lac tons. It would be advisable to plan for the production of this quantity of paper because of the usual time lag in planning things in forestry and their actual fulfilment.

3. TOTAL QUANTITY OF RAW MATERIAL REQUIRED

Assuming the conversion factors of 40% and 90% air-dry weight of raw material for* chemical and mechanical pulp respectively, our annual requirements of raw material work out as under :—

(*A*) *By 1956*

Kind of paper	Quantity of paper aimed at in tons	Raw material required in tons
Writing and printing, wrapping and kraft papers	3,00,000	7,50,000
Newsprint	1,00,000	1,50,000†
Total ..	4,00,000	9,00,000

* The conversion factor for sabai grass is only 33%. But as it is being used in comparatively much smaller quantities a uniform rate of 40% has been adopted.

† Includes Raw material required for manufacturing the chemical pulp necessary for admixture.

(B) By 1961

Kind of paper	Quantity of paper aimed at in tons	Raw material required in tons
Writing and printing, wrapping and kraft papers	4,50,000	11,25,000
Newsprint	1,50,000	2,25,000
Total ..	6,00,000	13,50,000

4. REQUIREMENT OF RAW MATERIAL FOR THE SMALLEST ECONOMIC UNIT

The smallest economic unit for producing writing and printing paper may be taken as one that can produce 30 tons of paper per day of 24 hours or 9,000 tons per year. This means a consumption of about 22,500 tons of raw pulping material per annum. The smallest economic unit in the case of newsprint should have a capacity of 100 tons per day or 30,000 tons per year. This will need about 45,000 tons of raw material per annum.

5. CONSIDERATIONS FOR THE CHOICE OF RAW MATERIAL

Paper is composed of cellulosic vegetable fibres. Theoretically, therefore, the sources of raw material for the paper industry should be unlimited. Practical considerations including the present state of technological development of the industry, preclude the use of a vast majority of these sources. The main requirements of a suitable raw material are :—

(i) The fibres should be long enough. The cellulose content should be high and the non-cellulose constituents should be capable of being removed with ease.

(ii) Large quantities of the raw material should be available in sustained quantities.

(iii) Since the industry cannot afford to pay high prices for the raw material, it should be cheap enough. The prices per ton of bamboos and *sabai* grass (air-dry) delivered at factory site in 1950 were Rs. 80 to Rs. 120 and Rs. 80 to Rs. 110 respectively.

(iv) For mechanical pulp the wood should be white in colour or nearly so. It should be free from defects such as rot, excessive knots, pitch pockets, etc.

6. RAW MATERIALS SUITABLE FOR THE PURPOSE

The following raw materials of forest origin tested at the Forest Research Institute, Dehra Dun, are considered suitable for making paper :—

(A) Newsprint

Serial No.	Species	Distribution	Remarks
1	*Abies pindrow* (Silver fir).	Western Himalayas from Nepal to Afghanistan at altitudes of 7,000 to 11,000 feet.	
2	*Picea morinda* (Spruce).		
3	*Pinus longifolia* (Chir-pine).	The Himalayas and the Siwaliks from Bhutan to Afghanistan at altitudes of 1,500 to 6,000 feet.	
4	*Broussonetia papyrifera* (Paper mulberry).	Native of Siam, Burma and Japan. Has been tried successfully over the greater part of India.	

(*B*) *Printing and writing papers*

Serial No.	Species	Distribution	Remarks
1	*Abies pindrow* (Silver fir).	..	Yield long-fibred pulp and can, therefore, be used for the purpose without admixture with other species.
2	*Picea morinda* (Spruce).	..	
3	*Pinus longifolia* (Chir-pine).	..	
4	Bamboos.	All over India excepting the dry thorn forests.	
5	*Eulaliopsis binata* (*Bhabar, Baib, Sabai*).	Practically all over India on poor soils and broken country.	
6	*Broussonetia papyrifera* (Paper mulberry).	..	
7	*Boswellia serrata* (*Salai*).	Common throughout India in the tropical deciduous forests.	Yield short-fibred pulp which has to be mixed with long-fibred pulp.
8	*Lannea grandis* (Syn. *Odina wodier*) (*Jhingan*).	Common throughout India in the tropical deciduous forests.	
9	*Sterculia campanulata* (*Papita*).	Deciduous forests of Andamans.	
10	*Helicteres isora* (*Maror phali*).	Sub-Himalayan tract, from Jhelum eastwards, throughout Central India and the Western Peninsula.	
11	*Arundo donax.*	Marshy lands, all over India—especially in the Tarai Tract.	
12	*Phragmites karka.*	Swampy areas of Assam and Bengal.	
13	*Imperata arundinacea* (*Ulla* grass).	A troublesome weed grass found all over the country especially in the moist locations.	

7. RAW MATERIALS IN USE

The paper industry in India has so far used Bamboos and sabai grass (*Eulaliopsis binata*) to the almost complete exclusion of pulp woods. Thus during 1950 it used about 2,25,000 tons of bamboos (mostly *Dendrocalamus strictus* with small quantities of *Bambusa arundinacea* and *Ochlandra travancorica*) and 80,000 tons of *sabai*. Only a very small quantity of wood was used for making writing and printing papers and that too by only one of the sixteen mills. If this case *Boswellia serrata* chemical pulp was used in mixture with bamboo pulp. The reasons for the popularity of bamboos and sabai are the high quality of pulp they yield and their availability in large enough quantities at reasonable prices.

8. SIZE OF WOOD REQUIRED FOR PULPING

Wood down to about 6 inches diameter is generally utilized for mechanical pulp (newsprint). This limit in the case of chemical pulp is about 2½ to 3 inches.

9. NOTES ON THE IMPORTANT SPECIES SUITABLE FOR THE INDUSTRY

(i) *Abies pindrow* (Silver fir), *Picea morinda* (Spruce).—Extend throughout the Himalayas from Nepal to Afghanistan between 7 to 11 thousand feet altitude and usually occur in mixture together with varying proportions of other species. They form extensive crops which have not so far been properly surveyed and exploited. They rank amongst the world's best pulp-woods but have not so far been utilized for this purpose in India on account of the prohibitive cost of extraction from these high altitudes. Due to lack of demand their silviculture and natural regeneration problems have not been systematically studied. They can both be raised artificially by direct sowings or by transplanting.

(ii) *Pinus longifolia* (Chir pine).—Found in the Himalayas from Bhutan to Afghanistan at altitudes of 1,500 to 6,000 feet. It is a remarkably gregarious species which occurs extensively as a pure crop. Troup has estimated it to occupy 3,230 square miles excluding Sikkim, Bhutan, Nepal, Mandi and N.W.F.P. States. It can be regenerated both naturally

and artificially with ease. It is being tapped for resin on a large scale. Also, it is one of our important timber species, being in great demand for railway sleepers, constructional purposes and other miscellaneous uses. Recent research at the Forest Research Institute, has shown that twisted fibre in Chir is no handicap from the pulping point of view. The paper industry cannot possibly compete for supplies of raw material with the timber industry but twisted trees and small thinnings unfit for timber, lops and tops and other waste material left over after exploiting the trees could all be utilized for paper pulp.

(iii) *Broussonetia papyrifera* (Paper mulberry).—A native of Japan, Siam and Burma where its bast has been used for the manufacture of high quality paper since ages. It is reasonably frost hardy and can be raised in localities with annual rainfall above 35″. It has been grown successfully at Dehra Dun, Saharanpur, Changa Manga and Lahore (probably with irrigation), Calcutta, Nagpur, Chandanthode, Begur and Top Slip. It can be propagated artificially from transplants, stumps or branch cuttings and regenerates with ease naturally from root suckers, coppice shoots as well as seed. So great are its powers of natural reproduction that it is difficult to eradicate once it has taken possession of a site. Paper mulberry is, therefore, usually worked under the simple coppice system.

Paper mulberry is an extremely fast growing species. One to four growth rings per inch are quite common and it usually attains a height of 50 to 70 feet. It is worked on a 3 years rotation in Japan though for Dehra Dun a 10 years' rotation is indicated.

Broussonetia has been tried for the manufacture of newsprint at the Forest Research Institute and has been found to be quite suitable for the purpose. On account of its fast rate of growth and the ease with which it can be grown and later on worked, it holds out a high promise to solve our newsprint problem. The necessity of starting large scale plantations of *Broussonetia papyrifera* is therefore obvious.

(iv) *Bamboos*.—Bamboos, as a general rule, are good pulping materials. Due to its easy availability *Dendrocalamus strictus* is the most commonly used species. In addition to it small quantities of *Bambusa arundinacea* and *Ochlandra travancorica* are used in areas where they are available.

Dendrocalamus strictus or the male bamboo is found in the deciduous forests throughout the greater part of India except in North Bengal and Assam up to 3,500 feet altitude. It sometimes occurs more or less pure with almost no tree growth, but more usually forms an under-story or a mixture in the deciduous forests.

Bamboo regeneration has not generally been a serious problem. It regenerates naturally from seed after a gregarious flowering. It can be artificially propagated by direct sowings, transplants or rhizome cuttings.

Dendrocalamus strictus is the mainstay of the Indian paper industry on account of its easy availability in large quantities at economic prices and the high quality of pulp it yields. It is likely to remain the chief raw material for making writing and printing papers in future as well, because of the above factors and the absence of a serious rival in the field.

Although our total resources of this bamboo have not been surveyed it may safely be remarked that we are so far only tapping a fraction of the total area under the species. The cost of extraction and carriage over long distances to the mill site is perhaps the biggest limiting factor. The mills may have to be more rationally located in order to exploit the untapped area. But this could only be done after the survey referred to above has been made. The forest departments will also have to open out most of the bamboos bearing areas with the help of roads and paths.

Bambusa arundinacea.—A large thorny bamboo found throughout the greater part of India excepting the Himalayan and sub-Himalayan tract and the valley of the Ganges. It is common in Orissa, the Circars and Carnatic and is most abundant in the Western Ghat forests from Kanara southwards, particularly on flat ground near rivers and streams. It is widely cultivated especially near the villages. It can be propagated by direct sowings of seed soaked in cold water for 48 hours or by planting offsets.

Ochlandra travancorica.—It is an erect tufted reed-like gregarious bamboo. The species possesses the longest fibre and has given the largest yield of pulp. It is found in the Ghats between Travancore and Tinnevelly at 3 to 5 thousand feet covering vast areas. The silviculture of the species, especially the methods of propagating it, do not appear to have been studied.

(v) *Eulaliopsis binata* (*Sabai, Baib, Bhabar* grass).—*Sabai* is a perennial grass occurring throughout India in the hilly and broken country up to an elevation of about 4,000 feet on exposed slopes and hill-tops with poor soils. It is hardy both to drought and frost. Due to its thrifty nature it thrives best on poorest soils. On rich sites it cannot stand the competition of other grasses.

Natural regeneration from seed is satisfactory on suitable lands. It can be easily propagated by planting tufts of roots broken off from larger clumps or from nursery transplants. An espacement of 2×2 feet is generally favoured. *Eulaliopsis* is an excellent soil binder for landslips and eroded lands. It can be profitably used for afforestation work in ravines and degraded lands around the villages. It yields good quality printing paper and also enjoys a ready market for rope making and other similar purposes. On account of the quick and annual financial returns this grass is capable of yielding from lands which normally will not bear any of the commercially important timber species, it deserves greater attention from the forest departments.

(vi) *Boswellia serrata* (*Salai*).—*Boswellia serrata* is one of the common and usually gregarious tree species occurring on dry hills throughout the greater part of India. It is a strong light demander with remarkable vitality on account of which it is able to thrive and reach fair dimensions on poor soils and southern hotter aspects where practically no other tree would grow. Its coppicing power varies from being satisfactory to poor. Natural regeneration from seed is usually considered to be satisfactory. It is best propagated from large cuttings, over 4 inches in diameter, planted during the hot weather (April–May), well before the monsoons.

(vii) *Lannea grandis* (Syn. *Lannea wodier, Odina wodier*, Ver. *Jhingan*).—It is common throughout India and Andamans in the tropical moist and dry deciduous forests up to 3,000 feet or so, rare in the tropical semi-evergreen type and absent from the tropical wet evergreen type. It also does not extend into the driest parts of Rajputana.

Lannea is a good coppicer. Natural regeneration is usually considered to be adequate. It can be regenerated artificially with comparative ease by sowing broadcast or by planting entire plants, or stumps and branch cuttings.

Lannea is a fast growing species. The rate of growth and size attained vary with the quality of the site and rainfall. Whereas the largest size noticed on poor sites may be only 4 to 5 feet girth with a 10 to 15 feet long bole, in moister forests of Western Ghats, sub-Himalayan tract, Assam and Andamans trees with 8 to 10 feet girth with a straight clean cylindrical bole about 40 feet in length are fairly common.

10. SUGGESTIONS

(1) Reliable statistics about the availability of the various pulping raw materials in the country are sadly lacking. Our foremost necessity is to carry out a survey of the

various pulping materials, especially the conifers and the bamboos, from the point of view of their exploitation for the industry. This alone will enable us to assess correctly the over all position and to take steps to meet the present and future demands of the expanding industry.

(2) The problem of producing newsprint is most urgent. Spruce, silver fir and chir pine are the only species which might yield requisite quantities of raw material at once. The possibility of exploiting them for the purpose should be examined without further delay.

(3) *Broussonetia papyrifera* is the only broad leaved species which has so far been utilized for the manufacture of newsprint. Though an exotic, it has been successfully raised over various parts of the country. It is one of the fastest growing woods and is capable of being raised over a wide range of soils and climates. Cultivation of the species in large scale plantations is strongly recommended.

(4) Bamboos and sabai grass are our best raw materials for writing and printing papers. They are not likely to be replaced by the pulp woods as long as their supplies can keep pace with the requirements of the industry. The necessity of conserving, augmenting and scientifically exploiting our existing stocks of these species is self evident. Greater stress on the scientific management of bamboos, especially the fixation of correct felling cycles and the enforcement of the best felling rules is called for. Sabai grass is an excellent soil binder. It gives quick and annual financial returns. Its propagation in connection with the soil conservation and general afforestation work, especially in the Punjab and Uttar Pradesh, where it is actually being utilized by the paper mills should be encouraged.

IV. PENCIL INDUSTRY

1. LOCATION OF THE INDUSTRY AND AN ESTIMATE OF PRODUCTION AND CONSUMPTION OF PRODUCE.

Pencil making is a pre-war industry which received a great impetus during the last war. Two large factories are situated at Calcutta, and one at Madras. There are several moderate sized factories at Ahmedabad, Poona and in South India. In addition, there are a number of small factories which carry on work on a cottage industry basis. The local production now meets more than half of the country's demand for common quality pencils, and a portion of the demand for the special and high quality ones. The country's total demand for pencils is valued at about rupees fifty lacs per year.

2. THE QUANTITY OF TIMBER CONSUMED

The timber for the better quality pencils was previously imported from America in the form of slats. Recently, only African slats have been coming into the country. Indian timbers have been used mainly for the lower quality produce. The industry's annual consumption of timber is estimated at 2,500 tons or 1,25,000 cubic feet in squares.

3. QUALITIES THAT A GOOD PENCIL-WOOD SHOULD POSSESS

A good pencil-wood should be light in weight, pink or nearly so in colour, easy to machine and should not warp. In addition, it should possess good whittling properties. For obvious reasons the timber need not be available in large sizes. Smaller pieces, off-cuts, breakages and rejections can be conveniently utilized.

4. TIMBERS SUITABLE FOR SUPERIOR QUALITY PENCILS

The American incense cedar (*Libocedrus decurrens*) dominates the world pencil market to-day and it was imported by the Indian manufacturers, like their prototypes all the world

over, for high quality pencils. However, for sometime only the African cedar, (*Juniperus procera*), which is inferior to the American pencil cedar, has been coming into the Indian market. Recent work done at the Forest Research Institute has proved that, of the numerous woods indigenous to the Indo-Pakistan sub-continent, *Juniperus macropoda*, *Cupressus torulosa* and *Cedrus deodara* can produce first grade pencils—the last two after suitable treatment. They are as good as the American cedar, and are all decidedly superior to the African cedar. *Juniperus macropoda* does not occur in any appreciable quantity in India, and due to the extreme difficulty in regenerating it and its slow growth, the raising of large scale plantations of this species is out of question. Thus we are left with only two good quality pencil woods, *deodar* and cyprus. These species are fast becoming popular with the industry. A serious hurdle in the way is that the existing factories are situated at great distances from the timber markets in the Punjab and western Uttar Pradesh and thus cannot economically import the timber in the raw. They want the wood in the form of ready made slats and we have, so far, no slat making factory worth the name. Such factories could be most conveniently situated near the timber depots in the plains or near the forests in the hills.

5. TIMBERS SUITABLE FOR INFERIOR QUALITY PENCILS

A large number of woods have been tried for this purpose from time to time. Those considered suitable after treatment are listed below in the order of merit :—

Serial No.	Species	Distribution
1	*Hymenodictyon excelsum.*	Deciduous forests throughout India.
2	*Lophopetalum wightianum.*	Western Ghat evergreens from Konkan southwards.
3	*Alstonia scholaris.*	Sub-Himalayan tract, ascending to 3,000 feet, from Yamuna eastward. Western Peninsula mostly in deciduous forests.
4	*Kydia calycina.*	Deciduous forests throughout India.
5	*Sapium sebiferum.*	Native of China, cultivated in N.W. India.
6	*Pinus excelsa.*	Himalayas from Bhutan to Afghanistan mostly from 6,000 to 10,000 feet.

6. NOTES ABOUT THE IMPORTANT SPECIES SUITABLE FOR THE INDUSTRY

(i) *Cedrus deodara* (*deodar*) is one of our three most important timbers and occurs in the Himalayas from Kashmir to Nepal at altitudes of 4,500 to 8,000 feet. Its silviculture and regeneration technique is too well known to need any repetition here. It is the only superior quality Indian pencil-wood which is available in large enough quantities at present. It is steadily gaining in popularity with the pencil industry and there is a great likelihood of its completely ousting the foreign timbers from this sphere.

(ii) *Cupressus torulosa* (*devidiar*).—It occurs at 6,000 to 9,000 feet elevation in the outer Himalayas from Chamba to Nepal in the form of comparatively small patches of isolated trees. Usually it occupies dry, hot slopes avoided by the other conifers growing in the zone. Though commonly met on limestone rock and shale it is not fastidious about soil and climate. It has been easily cultivated outside its natural zone under a variety of conditions. As compared to *deodar*, the distinguishing feature of cypress is that it will grow well on exposed sites unsuited for or at the most capable of producing poor quality *deodar*. The tree attains the same size as *deodar* and has practically the same growth rate.

The natural regeneration of cypress is generally satisfactory around older trees provided the requisite amount of light and protection from cattle is forthcoming. It can be successfully regenerated under the shelterwood system. Artificial regeneration is not difficult.

Direct sowings in lines and patches give a fair amount of success. On rocky and exposed sites it is best propagated by transplanting 2 to 3 years old nursery stock. *Cupressus*, as already mentioned, is a better pencil-wood than *deodar*. It is a first class carpentry wood suitable for pattern making and other high quality work. It is also the best Indian timber for battery separators and for making vats for storage of corrosive chemicals. It has, therefore, a bright future before it and deserves far greater attention from the forester than it has so far received.

(iii) *Lophopetalum wightianum* (*Narkeli*).—A very large and fast growing evergreen tree of the Western Ghat evergreen forests from Konkan southwards. *Lophopetalum*, like so many other tree species, has come into prominence only recently and has not been much studied so far. It is a pronounced shade bearer and natural regeneration is considered to be usually adequate. Entire transplanting is perhaps the best method of raising it artificially which should be done under overhead shade.

Lophopetalum is one of the most commonly used timbers for second grade plywood, matches and inferior quality pencils. It is also suitable for plywood for the tea chests. It has, therefore, already become one of our most sought-after timbers.

(iv) *Hymenodictyon excelsum* (*Kuthan*).—Large deciduous tree, usually with a straight cylindrical bole, found scattered throughout the greater part of India in mixed deciduous forests, particularly common on loose dry deposits of boulders and debris.

Hymenodictyon is a strong light demander right from the seedling stage. Its minute sized seed which is liable to be easily washed away and the resulting tiny seedling with a slow growth rate in the first two-three years and susceptible to suppression by the weeds are the obstacles in the way of natural regeneration, which is usually inadequate. The species, however, is easy to regenerate artificially. It comes up readily from direct sowings in lines though it is often damaged by frost at Dehra Dun. Transplanting and stump planting too are quite successful. Transplanting can be done both during the monsoons and in winter. Plants with ball of earth do much better than with naked roots. Regular and frequent thinnings during the first two years are indispensable in all the cases.

Hymenodictyon has a fairly fast rate of growth. A stump at Dehra Dun gave 3 feet 11 inches girth at 41 years age. The timber is suitable for matches and plywood.

V. PACKING CASE INDUSTRY

1. GENERAL

The manufacture of packing cases constitutes an important and large industry which increased tremendously during World War II. Before the war, the demand for packing cases was limited, and the deal wood imported in the form of boards and finished box-shooks chiefly from Japan, Yugoslavia and British Columbia, satisfied the major portion of the industry's requirements of raw material. During the war the imports of box-shooks came to a stop. On the other hand there arose a large demand for the packing cases. The expanding industry had to rely solely on the local timbers. Since the manufacture of packing cases does not involve the use of elaborate machinery, work is usually carried out in small factories. Production is mostly concentrated around the big industrial centres, though isolated units may be found all over the country.

2. ESTIMATE OF THE SIZE OF THE INDUSTRY AND THE QUANTITY OF TIMBER USED

Correct statistics of production are not available. The country's annual demand for the commodity is roughly estimated at Rs. 2,00,00,000 and it uses about 37,50,000 c. ft. of timber.

3. CONSIDERATIONS FOR THE CHOICE OF TIMBER

A good packing case wood should be light : a weight of 22 to 25 pounds per cubic foot being considered ideal. It should be reasonably strong and should possess good nailing properties. White or light-coloured woods are preferred. The actual use of a species in a particular place is determined by its cheapness and the ease with which it is available locally.

4. TIMBERS CONSIDERED SUITABLE FOR THE PURPOSE AND THOSE COMMONLY USED BY THE INDUSTRY.

Many timbers are used for packing cases. A list of suitable species is given below the more suitable out of these being distinguished by an asterisk mark :—

Serial No.	Species	Distribution
1*	*Abies pindrow.*	Himalayas 6,500 to 11,000 feet from Afghanistan to Bhutan.
2*	*Picea morinda.*	
3*	*Pinus excelsa.*	Himalayas 5,000 to 10,000 feet from Afghanistan to Nepal.
4*	*Bombax malabaricum.*	Throughout India up to 3,000 feet excepting the most arid parts.
5*	*Tetrameles nudiflora.*	Tropical moist deciduous and evergreen forests in sub-Himalayan tract, Western Ghats and Nilgiris.
6*	*Trewia nudiflora.*	Uttar Pradesh, Bengal, Assam, Chota Nagpur and Western Ghats.
7*	*Boswellia serrata.*	Throughout India in tropical deciduous forests.
8*	*Canarium euphyllum.*	Andamans, mostly in the deciduous forests.
9*	*Canarium strictum.*	Evergreen forests of the Western Ghats and Andamans.
10*	*Mangifera indica.*	Cultivated throughout India. Natural in Western Ghats, Satpuras, Assam, Chota Nagpur and portion of the sub-Himalayan tract.
11	*Excœcaria agallocha.*	Tidal forests on both sides of the Peninsula.
12	*Kydia calycina.*	Deciduous forests throughout India.
13	*Holoptelia integrifolia.*	Deciduous forests throughout India.
14	*Ailanthus excelsa.*	Mixed deciduous forests of the Peninsula and Sal forests of Central India.
15	*Ailanthus grandis.*	Sikkim and Assam.
16	*Ailanthus malabarica.*	Evergreen forests of the Western Ghats.
17	*Anthocephalus cadamba.*	Nepal, Bengal, Assam, Northern Circars and Western Ghats.
18	*Sterculia campanulata.*	Deciduous forests of Andamans.
19	*Sterculia alata.*	Evergreen forests of the Tista valley, Sikkim, the Duars, Assam, Chota Nagpur and Western Ghats.
20	*Alstonia scholaris.*	Sub-Himalayan tract up to 3,000 feet from Yamuna eastwards and Western Peninsula.

5. NOTES ON SOME OF THE SUITABLE AND PROMISING SPECIES

1. *Abies pindrow.*—Please see para 9 of the note on the "Paper Industry".
2. *Ailanthus excelsa.*—Please see para 6 of the note on the "Match Industry".
3. *A. grandis.*—Please see para 6 of the note on the "Match Industry".
4. *A. malabaricum.*—Please see para 6 of the note on the "Match Industry".
5. *Anthocephalus cadamba.*—Please see para 6 of the note on the "Match Industry".
6. *Bombax malabaricum.*—Please see para 6 of the note on the "Match Industry".
7. *Boswellia serrata.*—Please see para 9 of the note on the "Paper Industry".
8. *Canarium euphyllum.*—Please see para 6 of the note on the "Match Industry".
9. *C. strictum.*—Please see para 6 of the note on the "Match Industry".
10. *Holoptelia integrifolia.*—Please see para 4 of the note on the "Bobbins Industry".
11. *Kydia calycina.*—Please see para 6 of the note on the "Match Industry".

12. *Mangifera indica.*—Please see para 7 of the note on the "Plywood Industry".

13. *Picea morinda.*—Please see para 9 of the note on the "Paper Industry".

14. *Sterculia campanulata.*—Please see para 6 of the note on the "Match Industry".

15. *Tetrameles nudiflora.*—This is a lofty deciduous tree of the moist tropical forests, deciduous to evergreen, found in the sub-Himalayan tract and outer hills from Uttar Pradesh to Assam, Chittagong, Burma, the Western Ghats and the Nilgiris up to 3,000 feet.

Natural regeneration is often adequate under a light canopy. It appears that the species could be regenerated naturally by some sort of seeding fellings combined with weedings. The seed ripens from April to June. It does not store well and should be sown immediately after collection. Germination is usually poor. In Bengal it is raised by line sowings 6 feet apart. Recent experimental work indicates that transplanting and stump planting are much more satisfactory than direct sowings and branch cuttings also do fairly well. The species is a fast grower and can generally hold its own against weeds. In Assam 2 year old plants raised from one year old stumps are reported to give an average height of 11 feet.

The average annual girth increment in Bengal and Burma is about 1·7 inches. In Madras the tree is supposed to reach 6 feet girth in 30 to 40 years on good sites.

Tetrameles is suitable for growing in plantations in mixture with shade bearing species.

16. *Trewia nudiflora.*—Please see para 6 of the note on the "Match Industry".

VI. AIR CRAFT TIMBERS INDUSTRY

1. Present Position

The Aircraft Industry in India, is still in its infancy. There is only one factory at Bangalore which was constructed to carry out repairs to the aeroplanes in use and to serve as a sort of assembly plant. The construction of aircraft being of vital importance for any country which wants to pull its weight in the world affairs, the industry has been receiving proper attention from the national government since independence, and has already made some headway towards producing an all *Swadeshi* plane. The demand for aeroplane timbers, though very much limited at present, is bound to increase as the industry develops.

2. Purposes for which Timber is Required in Aeroplane Construction and some Considerations for the Choice of the same.

Timber is required mainly for two purposes in the construction of aeroplanes, (1) for main members and (2) as material for stream lining struts and braces and for packing the space between various parts to isolate them against vibration and to make the body sound proof. Due to the great risk involved in flying and the high cost of the planes the specifications for both these categories are very exacting. For the main members the timber should be sound, free from knots, straight grained, light in weight, and at the same time should possess high strength properties. The growth should have been uniform, only pieces with 8 to 16 growth rings per inch being accepted. The timber should also be available in large lengths. In America pieces up to 20 feet long are often taken out and used. For the second purpose lightness in weight coupled with minimum required strength, resilience and sound proofing properties are the chief considerations. In the international market, a weight of up to 14 pounds per cubic foot is considered to be satisfactory. The timber has, of course, got to be perfectly sound and free from knots.

3. TIMBERS SUITABLE FOR AIRCRAFT CONSTRUCTION

(*a*) For main members.

Serial No.	Species	Distribution	Remarks
1	*Picea morinda* (Spruce).	Himalayas from 6,000 to 11,000 feet and from Afghanistan to Bhutan.	These alone come up to international standards.
2	*Abies pindrow* (Silver fir).		
3	*Michelia champaca* (*Champa*)	Nepal, Bengal, Assam and Western Ghats up to 3,000 feet.	Possible alternatives for Nos. 1 and 2 though inferior to them.
4	*Phœbe* species (*Bonsum*).	Bengal and Assam hills.	
5	*Polyalthia fragrans*.	Western Ghats evergreen forests.	

(*b*) Materials for sandwiching the various parts and for stream lining the struts and braces.

Serial No.	Species	Distribution	Remarks
1	*Ochroma lagopus* (Balsa).	Tropical wet evergreens of West Indies, Central America and South America.	World's best timber for this purpose. Pieces with 8–14 lb. wt./c. ft. accepted commercially.
2	*Cryptomeria japonica*.	Exotic from Japan grown in small plantations near about Darjeeling.	A possible, though inferior, substitute for Balsa.

4. NOTES ON SOME OF THE SUITABLE SPECIES

(i) *Picea morinda*, (ii) *Abies pindrow*.—For distribution, silvicultural characters and position regarding regeneration please see para 9 of the note on the "Paper Industry". Attempts were made to exploit these species for the Aircraft Industry during World War II, but the results were rather poor. Presence of knots, rot, and unevenness of growth accounted for wholesale rejections. Extraction was another difficulty. This points out to the necessity of (1) dedicating suitable portions of the easily accessible forests for meeting the requirements of the industry, (2) scientific pruning of these crops in the sapling and young pole stages and (3) the introduction of a well planned of light and frequent thinnings from the young pole stage onwards. Debudding of young plants has proved to be very helpful in other countries in the production of knot-free timber and is worth trying on these conifers.

(iii) *Michelia champaca*.—A tall, handsome, evergreen tree with a long, clean and cylindrical bole, usually attaining a height of 110 feet or more and girth 10 feet and over. It is wild in the eastern sub-Himalayan tract and lower hills (Nepal, Bengal and Assam), the Western Ghats and South India up to 3,000 feet. It has been much cultivated in other parts of the country, especially around temples for the sake of its fragrant flowers. It is a moderate light demander and thrives best in damp situations with deep soil.

Natural regeneration of *Michelia* is usually plentiful around the mother trees. The tree seeds late in August which is too late for direct sowing. Artificial regeneration is, therefore, accomplished with the help of nursery stock. As the seed loses viability quickly, it should be sown in the nursery as early as possible. For transporting, the seed should be kept within the fruit or mixed with powdered charcoal. The plants can be transplanted with naked roots or with ball of earth. As they are rather sensitive, they require care in handling. Artificial regeneration can also be had by using root and shoot cuttings.

Michelia is a fast growing species. The sample plots from Bengal suggest the following average rate of growth for uniform crop :—

Age	Average height	Average diameter
	feet	*inches*
5	30	3·4
10	51	5·4
15	66	7·2
20	75	8·8
25	80	10·0
30	84	10·9
35	86	11·6

In addition to being a possible substitute for spruce and silver fir in aircraft construction, *Michelia* is an excellent wood commonly used for plywood, light furniture, household fitments, cabinet making, boards and joinery work, boat building, box shooks and bentwood work. For producing aircraft timber the above remarks regarding the necessity of raising the species in accessible and carefully tended plantations apply in this case too.

(iv) *Ochroma lagopus* (*Bombaceæ*)* is the source of the famous Balsa wood of commerce and is indigenous to the American tropics from West Indies and Southern Mexico to Bolivia and Peru in North-West South America. Nine-tenths of the Worlds supplies during the last war came from Equador, due mainly to the favourable currency exchange ratio. Attempts have been made to cultivate it in a number of countries but the species has proved to be a very tricky one. It has been successfully introduced in Ceylon in recent years. Madras has taken lot of interest and a few trees exist probably at Kannoth (altitude 500 feet and rainfall 166 inches). A small quantity of seed could be had from the Madras Silviculturist. A detailed note on Balsa wood by M. B. Raizada was published in the *Indian Forester* for April, 1947, and is recommended to those interested in raising its plantations.

In its native country Balsa mostly occurs in low lands and foot-hills, usually considerably below 3,000 feet, and avoids soils effected by brackish or salt water. Though scattered trees occur in virgin forest, it is characteristic of second growth types often invading in masses the newly cleared sites or abandoned cultivation. It requires a rich loamy soil, preferably alluvial, high temperatures and humidity and plenty of moisture coupled with good drainage. Experience in Ceylon shows that it is best grown along rivers and perennial streams where the roots can force through the soil quickly and get to water.

Ochroma lagopus being a very strong light demander, requires full overhead light right from the beginning. Transplanting has succeeded in some cases and utterly failed in others. Only basketed or potted plants, or plants grown in *donas* or bamboo tubes are likely to succeed. Direct sowings are preferred in many places. In either case a close initial spacing ($1\frac{1}{2} \times 1\frac{1}{2}$ feet to 2×2 feet) is favoured in order to avoid branching. A thorough burn, before sowing or planting, is regarded absolutely essential. The seedlings are extremely fragile and easily damaged during tending or by wind, insects and disease. The first weeding is, therefore, delayed till the plants are about 10 feet in height and $1\frac{1}{2}$ to 2 inches in diameter. At this time they are spaced to about 4×4 feet. The tree is very fast grown, the growth rate varying from place to place. It reaches the maximum size in 10 years, but the wood by this

* NOTE :—In 1919 W. W. Rowlee split up *O. lagopus* into the species (1) *O. lagopus* in the West Indies ; (2) *O. concolor* in Guatemala, Hondoras, Br. Honduras, Yucatan ; (3) *O. limonensis* in Costa Rica, Panama, Br. Honduras ; (4) *O. grandiflora* in Equador ; (5) *O. venutina* in the Pacific coast of Central America ; (6) *O. bicolor* in Costa Rica, Br. Honduras ; (7) *O. boliviana* in Bolivia and (8) *O. obtusa* in Columbia. This sub-division has been questioned by a number of authors who contend that it rests upon characters that are all either ontogenetic variations or ecological adaptations. In any case, wood of all these species is very much alike and is known as Balsa wood.

time may be worthless. Balsa of commerce is obtained from trees of 4 to 6 years when they may be 50–60 feet in height and 12 inches in diameter.

Balsa wood varies in weight within wide limits—i.e., 5 to 21 lb. per cubic foot. The commercial samples usually vary between 8 to 14 pounds (average about 10 pounds) per cubic foot. It is remarkable for its lightness, buoyancy, heat insulating, vibration dampening and sound proofing properties and elasticity and strength as compared to its weight. Hence it is put to a great variety of uses such as life belts, floats for fishing nets and mines, life boats, hydroplane floats, aeroplane construction, heat insulation of refrigerators, packing cases for perishable food stuff, sound proofing, and vibration insulation. The wood has thus got a great future, and on account of its great strategic importance, it deserves far greater attention than it has so far received. Four specimens of Balsa wood grown in Madras showed variations in weight from 7·25 to 13 pounds per c. ft. and compared favourably with specimens from Ceylon and South America. This proves that good quality Balsa wood can be produced within the country.

(v) *Cryptomeria japonica.*—A large evergreen conifer, indigenous to Japan and China, where it attains a height of 150 feet or more and a girth of 20 to 25 feet. It is a very popular tree in Japan and the timber there is used extensively for a variety of purposes ranging from building construction to tubs and casks. *Cryptomeria* seed was brought to India in 1844 and the species has been planted to a considerable extent in the Darjeeling hills from 3 to 7 thousand feet and does best between 4 to 5 thousand feet. It has also been planted in the neighbourhood of Shillong, Simla and other hill stations but does not do so well in the Western Himalayas, as in the Eastern region of greater rainfall and humidity. For good growth it needs cool climate with abundant rainfall, great humidity and a good, well drained, deep and fertile soil.

In Bengal, *Cryptomeria* reproduces naturally in masses where the canopy has been suitably opened up, the ground cover is light and humus is not too deep. Artificial regeneration is best obtained by transplanting entire plants out in the open or under a very light shade. In Bengal the cones ripen from October to December and seed is sown broadcast in raised and shaded nursery beds during February. Germination is about 80% and the normal Indian practice is to use nursery stock 3 to 4 feet high and 2–3 years in age.

Cryptomeria japonica plantations in Japan are usually managed on a rotation of 120 years. The growth under Indian conditions is much more rapid and has its effect on rotation and the quality of wood. Sample plot data collected from 13 plots in Bengal has given the following average growth figures for even-aged crops :—

Age	Crop height	Crop diameter
	feet	*inches*
5	14	2·5
10	26	4·3
15	38	6·0
20	50	7·6
25	61	9·1
30	69	10·5
35	76	11·8
40	82	13·0
45	88	14·1
50	93	15·2
55	98	16·1

Trees growing out in the open are usually much faster. A sixty-year old road-side tree at Rangirum (Bengal) was found to be 36 inches in diameter at b.h. and 106 feet in height.

Cryptomeria wood imported from Japan has 10 to 12 growth rings per inch on the average. Due to rapid growth in this country, the resulting timber is too light and weak to be of any use for structural purposes and packing cases, etc. The approximate weight per c. ft. in India is 12–22 lb. It is suitable for insulation boards and for wooden stoppers as a substitute for cork ones. It is considered to be a possible substitute for Balsa wood in the construction of aeroplanes but does not appear to have been actually tried for the purpose.

VII. SPORTS GOODS INDUSTRY

1. Location of the Industry and Position Regarding the production of Goods

The sports goods industry of India before partition was concentrated at Sialkot, in Western Pakistan. With the partition of the country, most of the capital and part of the skilled labour came over to India and this refugee industry is being built up afresh in East Punjab (Jullundur) and Uttar Pradesh (Meerut). Reliable statistics of actual production and the country's total requirements of sports goods are not available. The industry is, however, believed to be making a good headway.

2. Qualities that a Good Sports Goods Timber should Possess

A good sports timber should be strong, very elastic and tough, as light as possible in comparison to its toughness, and should be easy to bend with steam.

3. Timbers Suitable for the Purpose

Ash (*Fraxinus* spp.) is the most commonly used wood in the Western countries for hockey sticks and tennis and badminton racquets and is an excellent material for the purpose. It is not available in the country in commercial quantities. The mainstay of the Indian sports goods industry was the mulberry (*Morus alba*) timber from the irrigated plantations of the joint Punjab, all of which now lie in Western Pakistan. The mulberry had proved to be an excellent material for this purpose and is superior to the European Ash in steam bending qualities. There are no regular plantations of this species in India and the wood is in short supplies. That briefly is the core of the problem. In addition to mulberry, small, quantities of *Grewia* species and *Celtis tetrandra* have also been used, but they are inferior to the former and are also not available in large quantities. The English bat-willow (*Salix cœrulea*) is regarded to be world's best wood for cricket bats. The two species of willows (*Salix fragilis* and *Salix alba* × *Salix fragilis*) mainly growing in Kashmir, have been used by the Indian sports goods industry in the past and are considered to be quite suitable for high quality bats.

4. Notes on some of the Suitable Species

(i) *Morus alba* (Mulberry).—It is a moderate sized deciduous tree, probably indigenous to China and Japan where it is met with in a wild state. It has been widely cultivated since times immemorial for its fruit and shade and for rearing silk warms. Its timber came into prominence only recently and now ranks amongst the finest woods for sports goods. In India, it has been mostly cultivated in the North-Western zone from plains up to a considerable elevation in the Himalayas. It invaded the riverain and irrigated *sissoo* plantations in the Punjab, and was looked down upon as a weed in the beginning, but ultimately came to constitute 80% of the growing stock. Unless kept under check during the first 2–3 years it would exterminate *sissoo* which is the principal species in these plantations.

Mulberry is a good coppicer and regenerates itself naturally with ease from coppice and seed. Wide dispersal of seed takes place through the agencies of water, birds, man and probably jackals too. In the irrigated plantations of Western Punjab, water and the starlings were the most important agencies of distribution of seed. The young plant is shade bearing and has a fast rate of growth. It can, therefore, hold its own against weeds without outside help. Artificial reproduction is equally easy. Branch cuttings, entire transplants or stumps are best employed for this purpose though direct sowings also do succeed. The seed is sown in raised nursery beds any time after the middle of March if irrigation is available or otherwise in the beginning of rains. The beds have to be protected against sun and from drip during heavy rains. The small plants can be pricked out when 2–4 inches high though this is not done in the Punjab plantations. The nursery stock can be put out during the cold weather or at the onset of the next monsoon. For transplants best results are obtained by pruning the lower branches and plucking all but the top few leaves.

Experience in the West Punjab irrigated plantations has shown that mulberry does best under a certain amount of shade. It is liable to be broken by wind when grown as a pure coppice crop and also suffers from insolation if suddenly exposed. Mulberry grown in close plantation develops a long clean bole and gives much better timber for the manufacture of sports goods than the trees grown out in the open.

Rate of Growth.—*Morus alba* has a rapid rate of growth and reaches maturity at an early age. Thereafter the tree becomes hollow. The height growth culminates at a very early age and falls off rapidly after 10 years. The diameter increment on the other hand is maximum at the age of 18 to 20 years. Considering all these aspects, Mulberry in the West Punjab plantations is, therefore, worked on short rotations of 18 to 20 years. The growth figures for these plantations are summarized below :—

Age	Changa Manga medium quality*		Lahore division (from 8 s. plots)	
	Average height	Average diameter	Average height	Average diameter
	feet	*inches*	*feet*	*inches*
2	5	..	..	..
4	10	0·9	..	..
6	20	1·8	40	5·7
8	30	2·8	45	6·1
10	35	3·9	48	6·5
12	40	5·2	50	6·9
14	45	6·3	52	7·2
16	50	7·7	53	7·5
18	55	9·1	55	7·8
20	59	10·6	56	8·1
22	62	12·0	57	8·4
24	65	13·3	57	8·7

In addition to yielding high class timber for the sport goods, *Morus alba* is an excellent plant for raising silk worms, yields good fodder, fruit and shade. Its rapid rate of growth renders it suitable for cultivation in village fuel plantations. It, therefore, deserves more popularity and could be easily grown over most parts of the country.

(ii) *Salix* species (Willows).—The Indian sports goods industry has been using *Salix fragilis* and a cross between *Salix alba* and *Salix fragilis* for the blades of cricket bats.

* From Punjab Forest Records I (2) 1936, p. 33.

These two species though perhaps somewhat inferior to the English Bat-Willow (*Salix cœrulea*) are known to be quite suitable for this purpose. They are indigenous to Europe and Western Asia and are cultivated in Western Himalayas and Tibet. In India they are available in commercial quantities in Kashmir only and rank amongst the commonest trees of the main valley, cultivated along the banks of the various streams and water channels. They are being raised by the forest department along the lakes in regular plantations over a few thousand acres. They occupy an important place in the local economy as they supply cheap fuel to towns like Srinagar and raw material to the wicker work, match and sports goods industries.

For their best expression the above two species want a cold climate with some fall of snow in winter, plenty of moisture and good drainage. Hence they could probably be propagated on suitable sites in the Western Himalayas between 5,000–10,000 feet. Like other willows they are light demanders and strong coppicers and are easily raised by cuttings. In Kashmir stout cuttings over 1 inch in diameter are buried 18–24 inches into the soil. The planting is done during February or early March and the commonest espacement adopted is 6×6 feet.

VIII. BOBBIN INDUSTRY

1. General Position of the Industry and its Requirements of Raw Material

Bobbin making is an important industry located mainly at Calcutta, Bombay, Ahmedabad and a few other centres. It got impetus during the last war and is now faced with a certain amount of foreign competition. The country's total annual demand is estimated at 3½ crore of rupees, nearly half of which is covered by imports. The industry needs about 36,000 tons (18,00,000 c. ft.) of timber in the round annually.

2. Qualities which a Good Bobbin Wood should Possess

A bobbin wood should be a good turnery wood, close textured so that it can be given a smooth finish, medium in weight and sufficiently strong to stand up not only to the work required of it, but also to the strains set up in the high speed machines used in its manufacture.

3. Species Suitable for the Purpose

The following species are considered suitable for bobbins, those commonly used have been distinguished by an asterisk mark :—

Serial No.	Species	Distribution
1*	*Adina cordifolia* (*Haldu*).	Throughout India in deciduous forests.
2*	*Stephegyne parvifolia* (*Kaim, Phaldu*).	Throughout India in deciduous forests.
3*	*Hymenodictyon excelsum* (*Kuthan*).	Throughout India in deciduous forests.
4*	*Holoptelia integrifolia* (*Kanju*).	Deciduous sub-Himalayan forests of Punjab, Himachal Pradesh and Uttar Pradesh, Madhya Bharat, Chota Nagpur and the Peninsula.
5*	*Grevillea robusta* (Silver oak).	Indigenous to Australia, popular as cover crop over the coffee plantations in South India and cultivated as an avenue tree in various parts of the country.
6*	*Mangifera indica* (Mango).	Cultivated throughout India: Natural in Western Ghats, Satpuras, Chota Nagpur, Assam and portions of the sub-Himalayan tract.
7	*Michelia champaca* (*Champa*).	Nepal, Bengal, Assam and Western Ghats up to 3,000 feet.
8	*Gmelina arborea* (*Gamari*).	Throughout India in deciduous and semi-evergreen forests.
9	*Cedrela toona* (Toon).	Sub-Himalayan tract from Indus to Assam, Chittagong, Burma, Western and Eastern Ghats and other hills of the Peninsula.
10	*Phœbe goalparensis* (*Bonsum*).	Bengal and Assam hills.
11	*Zanthoxylum rhetsa* (*Mullilam*).	Western Ghats and coast from Konkan southwards.
12	*Amoora wallichii.*	Sikkim, Assam, Burma and Andamans.
13	*Betula* spp. (Birch).	Himalayas at higher altitudes.
14	*Acer* spp. (Acer).	Himalayas at higher altitudes.

4. NOTES ON SOME OF THE SUITABLE AND PROMISING TIMBERS

(i) *Acer* spp.—Please see para 4 of the note on the "Rifle Stocks".

(ii) *Adina cordifolia* (*Haldu*).—*Adina* is moderately common throughout the deciduous forests of India, Burma and Ceylon. It is usually scattered, though on well drained soil it may occasionally form almost pure crops. It attains large dimensions in the Kanara Forests of Bombay and in the forests of Kumaon Bhabar, where trees of 12 feet girth or over, are stated to be common.

The species does not reproduce itself satisfactorily under natural forest conditions, due to the minute size of the seed which requires a bare and broken up soil for germination. It is also readily grazed down by cattle and wild goats. Reproduction may, however, be profuse where the soil has been exposed and aerated or in burnt areas.

Artificial regeneration from direct sowings is very difficult as the tiny seed is easily washed away by rain. Nursery stock can be grown in well raised beds with fine sifted and sandy soil. Seed boxes are considered better than nursery beds as they are more easily protected against sun and rain. Powdered charcoal may be used for this purpose with great advantage. The growth of the seedlings in the first year is very slow, the stock for transplanting is ready only by the 2nd rains. The seedlings are rather sensitive to disturbance and should be transplanted carefully with a ball of earth. Plants previously pricked out in baskets or *donas* or bamboo tubes give greater success. Root and shoot cuttings also are stated to do well in some localities.

Haldu is a slow growing species. One sample plot in Saranda division, Bihar, indicates the following rate of growth for even-aged crops in the locality :—

Crop age	Crop height	Crop diameter
	feet	*inches*
65	73	15·4
70	78	15·9
75	83	16·3
80	88	16·7
85	93	17·0
90	..	17·3

Haldu is a fine timber used for a variety of purposes, from house construction and furniture making to high class plywood, and for such specialized purposes as bobbins and shuttles. As its supplies from the natural forest cannot keep pace with the increasing demand the species should be grown in large scale plantations.

(iii) *Cedrela toona*.—Please see para 7 of the note on the "Plywood Industry".

(iv) *Gmelina arborea* (*Gumhar, Gamari*).—It is a very fast growing, moderate-sized to large deciduous tree, with a heavy crown, found scattered all over India, especially in the deciduous forests.

Gmelina arborea is a strong light demander. Natural regeneration in the forest is not usually plentiful. It can, however, be easily raised by direct sowings, or from transplants and stumps. The seed is ripe in May and June. Germination is about 75% and the

seed keeps for about a month. Due to its fast growth it very easily holds its own against weeds.

Though quite popular for being grown in plantations some two decades back, it is not favoured much now. It is very much browsed by domestic and wild animals and greatly prone to attack by Loranthus and defoliators (*Calop pla*) and borers (*Dihammus* and *Alicide* spp.). Small scale plantations at the Experimental Garden of the Forest Research Institute, Dehra Dun have totally failed due to unknown causes.

The species being a strong light demander, older plantations become very open and the total yield per acre falls down. *Gmelina* should, therefore, be grown in mixture with suitable shade bearing species.

Rate of growth.—Six-year old trees at Lachiwala (Dehra Dun division), had an average height of 35 feet and an average girth of 21 inches. Data from 17 sample plots in Uttar Pradesh, Bengal, Assam and Bihar give the following average growth rate :—

Crop age	Crop height	Crop diameter
	feet	*inches*
5	41	5·1
10	57	7·3
15	65	8·6
20	71	9·3
25	75	9·7
30	78	10·0
35	81	10·3

(v) *Grevillea robusta* (The Silky or Silver Oak).—It is a medium sized, handsome evergreen tree with a conical crown, indigenous to New South Wales and Queensland and cultivated in the Nilgiris, Dehra Dun, Coorg and elsewhere principally as standards in tea and coffee plantations. In India it grows well between the altitudes of 2,000 to 6,000 feet. *Grevillea* is not particular as to soil and is easily raised by direct sowings or transplanting.

Grevillea is fast growing and reaches maturity at an early age. In Australia it takes 37 years to reach 24 inches diameter. The timber is suitable for furniture, panelling, packing cases, toys and veneering and plywood.

(vi) *Holoptelia integrifolia* (*Kanju*).—It is a large deciduous tree of the sub-Himalayan tract from the Chenab eastwards, ascending up to 2,000 feet, Madhya Bharat, Chota Nagpur, Northern Circars, hills of the Deccan and eastern slopes of the Western Ghats. It is usually found in mixed deciduous forests of a somewhat dry type where it is typical of thick boulder deposits. It is also often planted as an avenue tree.

Holoptelia integrifolia is a moderate shade bearer. It is somewhat frost tender and is known to suffer from frost in the Punjab plains. It requires good drainage : stiff soils are, therefore, unsuitable. Natural regeneration is usually adequate. It can be raised artificially by direct sowings or by careful transplanting of nursery grown stock. The seedling is slow grown in the first 2–3 years, hence weedings are necessary during early stages. The seed does not store well. The tree is a good coppicer and, due to its thrifty nature, is considered good for soil conservation work.

The rate of growth of *Holoptelia* is fairly fast, amounting to 2 to 6 growth rings per inch. I. D. Mahendru (vide I.F. Records, Vol. XV, Part VII) has given the following figures for diameter growth :—

Age	Diameter	
	At breast height	At 10 feet
	inches	*inches*
10	4·6	..
20	8·8	..
30	12·9	..
40	16·5	..
50	19·7	14·2
60	22·1	17·5
70	24·0	20·2
80	25·5	22·3
90	26·9	23·8
100	28·2	25·2

Holoptelia is suitable for 2nd grade plywood, bobbins, packing cases and planking, cotton reels, slate frames, carving and brushbacks and handles. It is, therefore, worth introducing on suitable sites.

(vii) *Hymenodictyon excelsum*.—Please see para 6 of the note on the "Pencil Industry".

(viii) *Mangifera indica*.—Please see para 7 of the note on the "Plywood Industry".

(ix) *Stephegyne parvifolia* (*Kaim*, *Phaldu*).—It is a large to medium sized deciduous tree found scattered throughout the tropical dry and moist deciduous forests of India, Burma and Ceylon. It reaches its best development on well drained and deep soils, but often grows gregariously in low lying clayey and badly drained localities.

The silvicultural characters of *Stephegyne parvifolia* and problems connected with its natural and artificial regeneration have not been studied in detail. Like *haldu*, it has a minute seed which gives rise to seedlings that are delicate in the first one or two years. Artificial reproduction by direct sowing is considered to be difficult. The species requires careful handling in the nursery. It is better to prick out the seedlings during the first rains, so that they are ready for transplanting by the beginning of rains next year.

IX. RIFLE STOCK INDUSTRY

1. General

Considerable quantities of timber are being used for gun stocks and rifle parts by the Government Ordnance Factories. Only selected woods are suitable for this purpose. The chief considerations are that the timber should be light, moderately hard, close grained and strong. Above all it must be capable of standing up to the high speed machines used in the manufacturing process and should not split, warp or move in service.

2. TIMBER SUITABLE FOR RIFLE STOCKS

Walnut (*Juglans regia*) is the only timber suitable for first quality gun stocks, and is being used all over the world for this purpose. Our limited resources of this wood have already been overworked. A search for alternatives has shown that Maple (*Acer* spp., mainly *A. cæsium*) and *Bird Cherry* (*Prunus padus* and *P. puddum*) can produce fairly good rifle parts. They are being used in small quantities.

3. PRESENT CONSUMPTION AND FUTURE REQUIREMENTS

An estimate of the country's requirements of timber for this item is not available. The present consumption is stated to be 'large' and a shortage of first quality material is being experienced. The future requirements are bound to remain more or less steady. Since these woods are required for defence purposes, they deserve special consideration from the forester.

4. NOTES ON THE SUITABLE SPECIES

(i) *Juglans regia* (Walnut).—*Juglans regia* is a large deciduous tree growing in the Himalayas at 4,500 to 11,000 feet from Afghanistan to Bhutan. It is chiefly found on well drained and fertile, though often bouldery, soil in sheltered situations, such as moist ravines or depressions. Commonly seen in mixture with other species, most of which are broad leaved, it also sometimes grows in pure patches. It is extensively cultivated for its fruit throughout the Himalayas and the Khasi hills.

Walnut is a light demander though it can stand a certain amount of shade in early stages. Natural regeneration in suitable localities is satisfactory, but nowhere adequate to meet the rising demand for its timber. It is easy to regenerate artificially by direct sowings, entire transplanting or stump planting. The seed is ready in September–October. Sowings, both in the nursery and the forest, are done during February–March. The nursery stock is put out during January–February next year when the plants are leafless. For timber, walnut should be grown in close crops, pure or in mixture. A mixture with *deodar* is very much favoured in the Punjab and is believed to improve the quality of *deodar* timber. Cultivated varieties are best propagated by budding and grafting and should be put out right in the open.

Juglans is a fairly fast growing species. The growth rate is said to increase from western parts of its habitat to the eastern, depending on the total rainfall. Troup mentions 15 growth rings per inch of diameter at breast height in Hazara as opposed to 6 rings per inch in Sikkim. Data collected from sample and diameter increment plots in Darjeeling and Kalimpong suggest the following growth figures for even-aged pure crops for that part of the country :—

Age	Crop diameter at b.h. in inches	Crop height in feet
10	3·1	25
15	4·1	42
20	5·0	55
25	5·8	63
30	6·6	..

Walnut is one of world's best woods for furniture, cabinet making and carving and gives extremely ornamental veneers and plywood. Its real importance lies in its being the most suitable wood for rifle parts and gun stocks and the Indian Ordnance department has been consuming the major portion of the country's yield. Since no really good substitute for this purpose has so far been found, walnut should be regarded as one of the strategic raw materials from the point of view of the country's defence, and the Forest Departments should take early steps to ensure its future supplies in sufficient quantities. This requires a well planned and sustained effort.

(ii) *Acer cæsium* (Maple).—It is the largest maple of the Western Himalayas and is chiefly found between 7,000 to 10,000 feet. Occasionally it descend to 4,000 feet and ascends to 12,000 feet. It is typical of grazing grounds and open glades, where it is more or less gregarious. It stands a moderate amount of shade in the early stages and requires full overhead light afterwards. Natural regeneration is usually plentiful in the neighbourhood of old trees. It can be easily raised in the nursery. Seed is sown in February–March. Regular watering is needed during the dry months as the young seedlings cannot stand drought. Pricking out is considered to be advantageous and the seedling is ready for transplanting in about 3 years time.

A. cæsium is rather slow growing, the mean annual girth increment varying between 0·2 to 0·7 inches.

(iii) *Prunus puddum* (Wild Cherry, *Padam*).—It is a moderate sized to large tree of the Himalayas, Khasi hills and Burma occurring between 2,500 and 8,000 feet. In Western Himalayas it is common in village lands as well as in the forest and stands a fair amount of shade. It is a good coppicer and also reproduces freely from root suckers and cuttings. Work on the artificial regeneration of this species has been rather limited, but there should be no difficulty in raising nursery stock.

(iv) *Prunus padus* (syn. *P. corunta*, Bird Cherry).—A moderate sized tree of the Himalayas, from Indus to Sikkim, growing between 6,000 and 10,000 feet often more or less gregarious, on rather moist pasture grounds and in forest glades. It is a moderate light demander, coppices well and produces root suckers freely. *Prunus padus* should be easy to raise by cuttings or sowings. Natural regeneration from seed is often abundant on newly exposed ground.

X. TOOL HANDLES INDUSTRY

1. General Position of the Industry

Handles are required for a large variety of tools and by far the larger proportion of these are hand-made on the spot by the user himself or by the village carpenter. Our consumption of machine-made tool handles, though only a fraction of the total, is estimated to be about 2 million per annum. These were mostly imported from America and Europe before the war, but the country is more or less self-sufficient in this respect now. The chief consumers are the various manufacturing and mining industries, engineering workshops, public works departments, railways and the Defence Forces. The manufacture of these handles constitutes a cottage industry, scattered all over the country and consuming, at a conservative estimate, about 1½ to 2 lacs cubic feet of timber, per annum.

2. Considerations for the Choice of Raw Material

The chief qualities required in a good tool handle timber are closeness of grain, toughness or a high shock resisting ability, hardness, non-liability to split and the absence of the

tendency to snap suddenly. The wood should, further, give a smooth finish, but need not be available in large sizes.

3. TIMBERS SUITABLE FOR THE PURPOSE

India possesses a large number of timbers suitable for tool handles. Some of these (e.g., *Anogeissus* spp.) compare well with the *Ash* and *Hickory* used in America and Europe for this purpose and thus rank among the world's best tool handle woods. The actual use of a particular species in a given area depends on local availability. A list of the suitable timbers is given below, those commonly used for machine-made handles have been distinguished with an asterisk mark :—

Serial No.	Species	Distribution
1*	*Anogeissus acuminata.*	Chanda district of Madhya Pradesh, Northern Circars.
2*	*Anogeissus latifolia* (*Bakli, Dhaura*).	Sub-Himalayan tract from Ravi to Nepal ascending to 3,000 feet. Madhya Bharat, Western Peninsula up to 4,000 feet in the Nilgiris. Deccan plateau and Eastern Ghats.
3*	*Anogeissus pendula.*	Rajputana and Bundelkhand, extending south to the Panch Mahals (Gujerat) and to Nimar on the Narbada river.
4*	*Grewia tiliæfolia* (*Dhaman*).	Chota Nagpur, Madhya Bharat and South India.
4a*	*Grewia elastica.*	Sub-Himalayan tract and Madhya Bharat.
5*	*Acacia arabica* (*Babul, Kikar*).	Indigenous in Sind, Rajputana, Gujerat and Northern Deccan. Commonly cultivated and naturalized through the drier parts of the country, up to 1,500 feet.
6*	*Morus alba* (Mulberry, *Tut*).	Cultivated mostly in North Western India up to considerable elevation in the Himalayas.
7*	*Parrotia jacquemontiana* (*Killar, Shtar*).	Kashmir and Chamba. 3,800 to 8,500 feet.
8*	*Kayea floribunda.*	Sikkim, Assam, Khasi hills up to 3,000 feet.
9*	*Olea ferruginea* (Syn. *O. cuspidata*).	Western Himalayas ascending to 6,000 feet.
10	*Mesua ferrea.*	Western Duars, Assam, Khasi hills, Andamans and Western coast from N. Kanara southwards.
11	*Dalbergia latifolia* (Rose wood, *Shisham*).	Sub-Himalayan tract from Oudh to Sikkim, Chota Nagpur, Madhya Bharat and South India.
12	*Dalbergia sissoo* (*Sissoo, Tahli*).	Sub-Himalayan tract from Indus to Assam up to 3,000 to 4,000 feet. Cultivated in most parts of the country.
13	*Ougenia dalbergioides* (*Sandan*).	Sub-Himalayan tract from Sutlej to Sikkim, ascending to 4.000 feet from Madhya Bharat southwards to Godavari and North Kanara.
14	*Quercus dilatata* (*Moru*).	Western Himalayas, 5,000 to 8,500 feet.
15	*Quercus incana* (*Ban*).	Western Himalayas up to Nepal, 4,000 to 8,000 feet.
16	*Diospyros melanoxylon* (Syn. *D. tomentosa*).	Dry mixed deciduous forests all over India.
17	*Cynometra polyandra.*	Khasi hills, Cachar.
18	*Mallotus philippinensis* (*Rohini*).	Sub-Himalayan tract and outer hills from Indus eastwards ascending up to 4,500 feet: Chota Nagpur, Indian Peninsula.
19	*Cassia fistula* (*Amaltas*).	Deciduous forests throughout India.
20	*Schleichera trijuga* (*Kusum*).	Sub-Himalayan tract from Sutlej eastwards up to 3,000 feet. Madhya Bharat and Western Peninsula.
21	*Tamarindus indicus* (*Imli*).	Cultivated throughout India.
22	*Dendrocalamus strictus* (Bamboo, *Bans*).	Deciduous forests throughout the greater part of India except in North and East Bengal and Assam.

4. The above species rank among the commonest in the country and are generally available in sufficient quantities. The total requirements of raw materials for the tool handle industry being rather limited, no special plantations for this purpose alone are necessary.

XI. BATTERY SEPARATORS INDUSTRY

1. GENERAL

The battery separators industry in India sprang up during the last war. The country's annual consumption of this commodity is valued at about Rs. 20,00,000 and the local production which is used mostly for replacement and repair work meets only about one-third of the total demand. In order to make the country self-sufficient in this respect the industry will require about 2,500 tons (1,25,000 c. ft.) of sawn timber annually, which, however, need not be available in large sizes.

2. CONSIDERATIONS FOR THE CHOICE OF RAW MATERIALS

A timber suitable for battery separators should possess good machining properties should be resistant to the action of mineral acids and should be free from chemicals likely to, interfere in its functioning.

3. LIST OF SUITABLE SPECIES

The list of timbers suitable for battery separators, in the order of merit, is given below :—

Serial No.	Species	Distribution
1	*Cupressus torulosa* (Cyprus).	Himalayas 6,000 to 9,000 feet from Chamba to Nepal.
2	*Abies pindrow* (Silver fir).	Himalayas from 6,000 to 11,000 feet from Afghanistan to Bhutan.
3	*Picea morinda* (Spruce).	
4	*Cedrus deodara* (*Deodar*).	Himalayas from 4,500 to 8,000 feet from Kashmir to Nepal.
5	*Michelia champaca* (*Champa*).	Nepal, Bengal, Assam and Western Ghats up to 3,000 feet.
6	*Adina cordifolia* (*Haldu*).	Deciduous forests all over India.

4. NOTES ON THE SUITABLE SPECIES

1. *Cupressus torulosa*.—Please see para 6 of the note on the "Pencil Industry".
2. *Abies pindrow*
3. *Picea morinda* } Please see para 9 of the note on the "Paper Industry".
4. *Cedrus deodara*.—Please see para 6 of the note on the "Pencil Industry".
5. *Michelia champaca*.—Please see para 4 of the note on the "Aeroplane Timbers".
6. *Adina cordifolia*.—Please see para 4 of the note on the "Bobbin Industry".

TIMBER FOR SPORTS GOODS

Interim report on the strength of Timber from Mulberry plantations

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SUMMARY

Before the partition of India, the Indian sports goods Industry was concentrated in or near Sialkot and the main timber used for the industry was mulberry (*Morus alba*) supplied from the Chhanga Manga and Lahore Plantations. All these places have now gone into Pakistan territory. Sports goods manufacturers who migrated into India, have been trying to re-establish their old industry but are confronted with the lack of a suitable timber and the matter was represented to the Government. Timber for sports goods must possess a combination of a number of special properties. Ash timber has been used in Europe and America. Indian mulberry was found to be suitable and the demand was met so long from large plantations in West Punjab.

Mulberry plantations are also being raised in Uttar Pradesh and the Andamans. The experiments described in this leaflet were undertaken to do a preliminary survey of the properties of the timber produced by these plantations. It is gratifying to note that the plantations are producing suitable timber for meeting the needs of the sports goods Industry. As it is a valuable tree for other purposes also, mulberry deserves to be raised on a larger scale in favourable localities.

SHORTAGE OF TIMBER SUITABLE FOR SPORTS GOODS

Before the partition of India, the Indian sports goods industry was concentrated in or near Sialkot—now in West Pakistan. The main timber used by the Industry was mulberry (*Morus alba*), which was supplied by the Chhanga Manga and Lahore plantations. Hockey sticks, badminton rackets and tennis rackets, racket frames, cricket stumps, etc., were made of mulberry. A large number of unfinished tennis rackets of mulberry amounting probably to several hundred thousands used also to be exported from India before the 2nd World War.

The sports goods industry suffered a severe set back after the partition. All mulberry plantations which were more or less concentrated in West Punjab went into Pakistan territory. A number of craftsmen and manufacturers from Sialkot were also displaced. Those that migrated into India settled down in Jullundur, Batala, Dehra Dun, Meerut, Delhi, Agra and other places and have been struggling to re-establish their old industry. They were at once confronted with the lack of suitable timber for the manufacture of sports goods in India.

PROPERTIES OF SPORTS GOODS TIMBERS

The requirements of a timber suitable for the manufacture of sports goods are very exacting. It must be as light in weight as possible in comparison to its strength properties. It should be strong, pliable, i.e., easy to bend, tough, i.e., capable of great shock resistance, easy to work and finish, capable of taking a good polish or stain and preferably light in colour. The timber must further be easy to propagate, quick growing and easy to coppice as second growth coppice timber has been found to be more suitable for sports goods in Europe and America where mostly ash timber is used for the purpose. It will, therefore, be seen that

finding a timber to fulfil all these requirements is a difficult problem. Mulberry was fortunately such a timber and it was grown in large plantations in the Punjab. It at once took the place of ash which is scarce in India and became the standard sports goods timber of India as a rival of ash.

PLANTATIONS OF MULBERRY

The cultivation of mulberry in India can be traced back to antiquity. It was then as also now, grown mainly as a food crop for silk worms as silk and sericulture are very old industries of India. Plantations of mulberry for the production of timber are, however, of a more recent origin. The Punjab plantations were probably the first of this type. Uttar Pradesh has also grown some plantations of mulberry. More plantations are being taken up at other places in India, as a result of representations by the sports goods manufacturers.

TESTING OF MULBERRY

Mulberry from the Chhanga Manga and Lahore plantations in Pakistani Punjab has already been tested. Results of preliminary tests from four divisions in Uttar Pradesh, namely, Bahraich, Etawah, Ramnagar and Saharanpur where mulberry plantations are being raised, are given in this report. Although the trees were still very young, being only about 15 years of age, they were fairly fast grown and had attained an average girth of over 40 inches at breast height and an average total height of 37 feet varying from 25 to 50 feet. The tests were done to find the quality of timber in order to determine if these plantations produced suitable material and if more plantations should be undertaken. Only two trees from each place were tested.

Tests were also done on another species of mulberry namely *Morus lævigata* occurring in Assam and the Andamans.

RESULTS OF STRENGTH TESTS OF MULBERRY—MORUS ALBA (GREEN)

Table 1 shows the results of strength tests on mulberry—*Morus alba*—from the Uttar Pradesh plantations.

The first two lines of Table 1 give the strength of mulberry from the Chhanga Manga plantations and ash from Chamba state. These are given for comparison as Chhanga Manga mulberry and ash are the standard sports goods timbers so far utilized in India.

The 3rd, 4th, 5th and 6th lines show the strength of the 4 Uttar Pradesh plantations separately and the 7th line gives their average strength. The 8th line gives the strength of mulberry from the Lahore plantations for comparison with Uttar Pradesh as it was of the same age as that of Uttar Pradesh, when tested.

ANALYSIS OF STRENGTH RESULTS

Comparing the strength of Uttar Pradesh mulberry—line No. 7 of the table,—with that of West Punjab mulberry from Chhanga Manga and ash—lines 1 and 2—it is seen that the specific gravity (Column 9) and weight of seasoned timber (Column 11) of mulberry and ash are practically similar. The bending strength (Columns 12 and 13) of mulberry from

Uttar Pradesh is somewhat lower. This is due to timber from young plantations and can be expected to improve with age. The modulus of elasticity of mulberry is considerably lower than that of ash showing that mulberry is more pliable and so easier to bend. This is a great advantage for mulberry. Impact strength of Uttar Pradesh mulberry (Column 14) is, however, considerably higher than that of ash and mulberry from both the plantations in Pakistan. As high impact strength in relation to weight is an important function of timbers suitable for the sports goods industry, mulberry plantations in Uttar Pradesh seems to be doing very well and producing high quality timber.

STRENGTH OF MULBERRY—MORUS LÆVIGATA—GREEN

Table No. 2 shows the results of strength tests on mulberry—*Morus lævigata* (Green).

In Table 2, line 3 shows the strength of *Morus lævigata* from Assam and line 4 that of *Morus lævigata* from the Andamans. Andaman timber seems to be from recent plantations being only about 16 years of age but has attained a good size, namely, an average girth of 48 inches and an average height of 40 feet. The timber from Assam is also fast grown. *Morus lævigata* from the Andamans compares very well with *Morus alba* from Uttar Pradesh and the Punjab. The timber from Assam shows somewhat lower impact strength but is as strong as ash timber in other respects.

SUMMARY

1. It is seen that the mulberry species tested are quick growing and so comparatively short rotation crops.
2. As the plantations of *Morus alba* in Uttar Pradesh are very young and timber from only two trees from each locality was tested in the green state, the results of these strength tests may be taken as tentative, and giving a preliminary indication of the quality of mulberry produced in Uttar Pradesh. The same remarks apply to *Morus lævigata*.
3. Due to its high impact strength in comparison to weight and its good bending property, mulberry timber from the Uttar Pradesh and Andaman plantations is coming very well up to expectations and producing suitable timber for meeting the needs of the sports goods industry. *Morus lævigata* from Assam is also of good quality and suitable for sports goods although somewhat less in impact strength.

CONCLUSIONS

Mulberry species seem to be an important tree crop both for forest plantations and for the village economy of rural India and deserve to be raised in the forest and in the country-side for the production of (*a*) Green fodder for cattle and silk worms by lopping (*b*) fire wood by short ratation (*c*) delicious edible fruit especially *Morus alba* and (*d*) above all for the production of an excellent timber for furniture and sports goods industries.

TABLE 1.—*Strength of*

Serial No.	Species	Locality	No. of trees tested	Age (Years)	Average girth over bark (Inches)	Average height of trees (Feet)	Seasoning
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
1	*Morus alba.*	Chhanga Manga, Punjab (P)	5	38	66	63	Green
2	*Fraxinus excelsior* (*ash*).	Chamba, Himachal Pradesh	..	..	..	..	Green
3	*Morus* spp. probably *M. alba.*	Bahraich, U.P. ..	2	14	42	25	Green
4	*Morus* spp. probably *M. indica.*	Etawah, U.P. ..	2	15	49	27	Green
5	*Morus* spp. probably *M. alba.*	Ramnagar, U.P. ..	3	15	33	42	Green
6	*Morus alba.*	Saharanpur, U.P. ..	1	16	52	52	Green
7	..	Uttar Pradesh, average ..	8	15	44	37	Green
8	*Morus alba.*	Lahore, Punjab (P) ..	5	14·5	30	35	Green

TABLE 2.—*Strength of*

Serial No.	Species	Locality	No. of trees tested	Age (Years)	Average girth over bark (Inches)	Average height of trees (Feet)	Seasoning
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
1	*Morus alba.*	Chhanga Manga, Punjab (P)	5	38	66	63	Green
2	*Fraxinus encelsior* (*ash*).	Chamba, Himachal Pradesh	..	..	..	..	Green
3	*Morus* spp. probably *M. lævigata.*	Assam	2	32	47	..	Green
4	*Morus lævigata.*	Andamans	5	16	48	40	Green

Mulberry (*Green*)

Specific Gravity Based on weight oven-dry and volume green	Per cent Moisture	Approximate weight of seasoned wood at 12% moisture lbs. per cu. ft.	Modulus of Rupture in Bending lbs. per sq. in.	Modulus of Elasticity in Bending 1,000 lbs. per sq. in.	Maximum height of drop (Inches)	Maximum Crushing Stress lbs. per sq. in.	Side Hardness lbs.	End Hardness lbs.
(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)
0·565	104·4	42	10,300	1,270	46	4,900	1,420	1,240
0·660	33·4	45	10,500	1,480	56	4,600	1,260	1,240
0·619	74·1	46	7,400	900	74	3,300	1,130	1,090
0·594	83·7	44	8,100	1,070	64	3,850	1,160	990
0·571	45·2	42	7,400	810	58	3,450	1,090	1,000
0·603	83·4	45	8,400	1,170	76	3,750	1,190	1,110
0·597	71·6	44	7,800	980	68	3,600	1,140	1,050
0·590	72·8	44	8,200	1,040	55	3,600	1,100	1,010

Mulberry (*Green*)

Specific Gravity Based on weight oven-dry and volume green	Per cent Moisture	Approximate weight of seasoned wood at 12% moisture lbs. per cu. ft.	Modulus of Rupture in Bending lbs. per sq. in.	Modulus of Elasticity in Bending 1,000 lbs. per sq. in.	Maximum height of drop (Inches)	Maximum Crushing Stress lbs. per sq. in.	Side Hardness lbs.	End Hardness lbs.
(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)
0·565	104·4	42	10,300	1,270	46	4,900	1,420	1,240
0·660	33·4	45	10,500	1,480	56	4,600	1,260	1,240
0·515	90·8	38	11,300	1,470	37	5,600	1,220	1,240
..	..	..	8,900	1,200	53	4,100	980	990

DISCUSSION ON "THE ROLE OF VEGETATION IN DESERT CONTROL"

BY J. BANERJI, I.F.S.
Deputy Inspector-General of Forests

1. Climatologically the hot dry regions of the world (B of Köppen) entwine roughly around 20° to 25° north and south latitudes. They extend westwards from Rajasthan to Arabia, North Africa, and Arizona in the United States of America in the Northern hemisphere. Similarly we have the Kalahari in South Africa, the Atacama in the Chile, and the deserts of Central and Western Australia, in the Southern hemisphere. These climates are caused primarily by the subsiding motion in the subtropical anticyclones. To this extent, therefore, deserts are inevitably conditioned by their position on the earth's surface, and no human effort, agricultural, pastoral, engineering, or atomic, can alter this zonal climatic set up of the globe.

2. Having classified the principal climatic zones of the world into 11 types, Köppen defines his 'B' (dry climate) type by the following formula :

r is less than, or $= 0 \cdot 44t - 8 \cdot 5$, where
r = mean annual rainfall in inches
t = mean annual temperature in °F.

As this formula did not take into consideration the significant differences in evaporation and, therefore, available moisture for vegetation, made by the maximum precipitation falling in summer, or winter, he further defined, and classified, B as follows :

Rainfall	Line between B (dry) and A (tropical rainy climates)	Line between BWh (dry hot desert) and BSh (dry hot Steppe)
1	2	3
1. Mostly in summer ..	$r = 0 \cdot 44t - 3$	$r = \frac{1}{2} (0 \cdot 44t - 3)$
2. Mostly in winter ..	$r = 0 \cdot 44t - 14$	$r = \frac{1}{2} (0 \cdot 44t - 14)$

Applying the above formula to Rajasthan, where the mean annual temperature is 76°F., we get the following boundaries :—

(*a*) Dry hot deserts or BWh = 0 to 15·22 inches mean annual rainfall.
(*b*) Dry hot Steppe or BSh = 15·22 to 30·44 inches mean annual rainfall.
(*c*) Tropical Savannah or Aw = 30·44 inches and above mean annual rainfall.

We might reasonably equate BSh climate to the "Northern desert thorn forest" of Champion which is occasionally found at places with a mean annual rainfall of even 10 inches. The predominant species here are :

(i) *Prosopis spicigera*,
(ii) *Salvadora oleoides*, and
(iii) *Capparis aphylla*.

From the vegetational point of view, the boundary between BWh and BSh may, therefore, be drawn at 10 inches isohyet, and that between BSh and Aw at 20 inches, where Aw is equivalent to "Southern Tropical Dry Deciduous Forests". This delimitation is not inconsistent with the current conception of desert or arid, and Steppe or semi-arid, regions of Rajasthan. Hence Köppen's formula, developed under foreign conditions, serves only to define the broad boundaries ; it requires local modification with reference to types, and floristic composition, of the vegetation, if a sharp outline is to be obtained. If the formula is applied rigidly, the semi-arid regions of Rajasthan, containing a definite type of forest with a characteristic flora has incongruously to be grouped under a treeless arid desert. For convenience sake, I have used Köppen's nomenclature, with this slight difference in meaning. In the absence of reliable data, it has not been possible to apply Thornthwaite's P–E index (precipitation effectiveness ratio), and T–E index (Thermal efficiency) to Rajasthan conditions. But here again suitable adjustment in the formula will perhaps be required.

3. In Rajasthan, as elsewhere in the world, the BSh (semi-arid) climate envelopes BWh (arid) climate. What is significant is that the BSh extends westwards into the Arabian Sea, as it does into the Atlantic ocean beyond Sahara, and into the Pacific Ocean beyond Mexico. As no human agency can interfere with the climate on the surface of the sea, it is obvious that man's activities have little to do with the broad microclimatic divisions of the world.

4. It is, however, the microclimate, or the meteorological and climatic conditions of the atmospheric layer below the level of meteorological instruments (2 metres) that can be successfully altered by the activities of man and his animals, and most frequently such conditions have been adversely affected by ruthless destruction of the vegetational mantle of the earth's surface. It is needless to stress that plants grow in the microclimatic zone and congenial conditions in the lowest atmospheric layers are essential for man to grow his food crops and fodder for cattle. Otherwise stable agricultural economy degenerates into a pastoral economy, which, with further deterioration, gives place to a nomadic society, and finally leads on to the extinction of all community life.

5. Forests, shelterbelts and vegetational covers alter the geometrical shape of the earth's surface offering more friction and resistance, and thus reducing the velocity of wind within the vertical space in which the plants are growing. It has been noticed by Geiger that the wind velocity decreases rapidly downwards to the top of trees, and then remains constant. The following table (after Geiger) will make the point clear :

Wind Velocity in a crop of Pines

Position	Height of Anemometer ft.	Wind velocity mph	Percentage
Above the tree crowns ..	55·3	3·6	100
At the top of the crowns ..	44·9	2·0	55
Within the tree crowns ..	34·6	1·5	42
Upper part of the bole ..	24·3	1·5	42
Lower part of the bole ..	13·9	1·5	42
Near the ground ..	3·6	1·3	36

Similarly, reduction of velocity has been noticed horizontally on the leeward side (lee vortices) of the shelterbelts and windbreaks standing across the direction of the wind.

When the wind velocity is 15 miles per hour, it is reduced to 60% at a distance of 5 times the height of the trees, and regains the original value at a distance of 30 times the height of the trees. The direct result of a reduction in wind velocity is that the sand-carrying capacity of the wind is greatly diminished, reducing, by a corresponding degree, the evil effects of wind-erosion. In a forest area, therefore, the turbulent mass exchange is smaller than that on bare ground.

6. Compared to bare soil, forests absorb larger quantities of incoming shortwave solar radiation, and emit smaller amounts of radiation in the long wave region. Hence the balance of radiation in a forest is favourable for an equable climate. Though forests with their millions of leaves and evaporating surfaces increase evaporation, on the whole the loss of heat by evaporation does not appreciably reduce their beneficial effects. The maximum temperature in the forest is reduced, the minimum temperature is increased. Owing to continuous evaporation from plant surfaces adding water vapour to the air, the humidity inside forests is high. "Occasionally the temperature difference between the forest and its environment may even produce a feeble circulation analogous to the land and sea breezes, with the forest assuming the role of the water, owing to its more moderate diurnal temperature variations". (B. Haurwitz and J. M. Austin).

7. Considering all these physical effects of vegetation and forests, the *ad hoc* Committee set up by the Ministry of Food and Agriculture, have suggested unanimously the creation and establishment of shelterbelts and forests along strategic lines in Rajasthan to combat the hostile aridity of the region. They have also recommended the establishment of a Desert Research Station at Jodhpur to carry out experiments on indigenous and exotic species. These eminently practical recommendations of this Committee, when implemented, are expected to bestow all the beneficial results of a microclimatic change to the regions in the vicinity of the forest belts. Nowhere in India are such steps a crying necessity. It is in this sense it is proposed to immobilize the Rajasthan desert.

THE CULTIVATION OF PYRETHRUM IN THE NILGIRIS (SOUTH INDIA)

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I. GENERAL

Among the numerous vegetable and chemical insecticides of the world, Pyrethrum occupies a unique place not only on account of its cheapness but also due to its wide applicability both in its pure form and in mixture with other insecticides. One of the most remarkable features of Pyrethrum is its lightning action on the insects and it is, therefore, invaluable in any campaign where a quick 'Knock down' is essential.

2. Pyrethrum (*Chrysanthemum cinnerarifolium*) belongs to the genus *Chrysanthemum*, family *Compositæ*. Although this genus contains more than one hundred species, only three are toxic to insects. They are *Chrysanthemum cinnerarifolium* (Treviranus) Boccone, *Chrysanthemum roseum*, Web and Mohr, and *Chrysanthemum marshalli*, Ascherson. Of these, only *Chrysanthemum cinnerarifolium* is important and used in the manufacture of the various Pyrethrum products of commerce.

3. *The history of Pyrethrum*—The use of Pyrethrum flowers for insecticidal purposes originated in Persia and was shrouded in great secrecy for a number of years. Pyrethrum powder, as an insecticide, was first introduced into Europe early in the nineteenth century by an Armenian merchant, who discovered the secret of its preparation while travelling in the Caucausus. The discovery of Pyrethrum as an insecticide was made accidentally by a German woman of Dubrovnick, Dalmatia, who picked a boquet of the flowers for their beauty. When the flowers withered, she threw them into a corner where several days later they were found surrounded by dead insects. She at once associated the death of the insects with the insecticidal properties of the flowers and started the business of manufacturing Pyrethrum powder on a small scale. The success of the venture was so immediate that it very soon became the most popular insecticide and a flourishing trade in Pyrethrum powder was established in Dalmatia. By 1840, an improved strain of *Chrysanthemum cinnerarifolium* was evolved in Dalmatia and rapidly ousted the Persian species from the European markets.

4. *Introduction of Pyrethrum into U.S.A.*—Pyrethrum powder was first introduced into America in 1860 and its popularity and demand increased day by day. Consumption of Pyrethrum increased from 600,000 pounds in 1885 to 3,000,000 pounds in 1919. By 1919, kerosene extract of Pyrethrum appeared in the market and soon replaced the powder for household purposes. By 1928, the use of the powder had almost completely ceased ; the quantity imported into the United States of America, however, increased from three million pounds in 1919 to sixteen million pounds in 1935. In 1926, as a result of considerable research, Pyrethrum extracts were for the first time adopted for horticultural purposes thereby opening a new and wide field for the use of Pyrethrum as an insecticide. Remarkable progress was made between 1924 and 1929 – thanks to the pioneering and classical researches of Staudinger and Ruzicka – it became possible to assay Pyrethrum and produce a Pyrethrum extract of standardized active principle.

5. *Introduction of Pyrethrum into Japan*—Pyrethrum was introduced into Japan from England in 1881. Between 1881 and 1896 Pyrethrum was tried in various places in Japan, and it was discovered that the mountainous island of Hokkaido, whose barren slopes and almost sterile soil, totally unfit for any other crop, was eminently suitable for Pyrethrum.

The cultivation of Pyrethrum which was started on a very modest scale in 1911 over an area of 380 acres, soon developed into a flourishing business and by the end of 1935, the area under Pyrethrum was 71,845 acres with an annual production of 23,555,000 pounds of dry flowers. Just before the outbreak of the last world war, Japan was producing a little over 70% of the world's supply of Pyrethrum and the island of Hokkaido contributed 64%. Japan virtually held the world monopoly in Pyrethrum from 1920 to 1937, and about 90% of her production was exported to the United States of America.

6. *Introduction of Pyrethrum into Kenya*—Pyrethrum was introduced into the Kenya colony in East Africa in 1928 where the soil and climate of the highlands of Kenya were found extremely suitable and the plantations were gradually extended. In 1934, there was an exportable surplus of 80 tons of dry flowers, in 1935 there was 600 tons and in 1937, 1,500 tons. With the entry of Japan into the last war an important source of Pyrethrum for the Allies was lost and every effort was made to extend the Kenya plantations as expeditiously as possible. Although the latest information regarding the quantity of Pyrethrum flowers produced in Kenya is not available, it is safe to assume that the position held by Japan before the war has altered appreciably and very soon Kenya will be the main source of Pyrethrum for the world. Moreover, due to the higher Pyrethrin content, the Kenya flowers are not only in great demand but also command a premium of 12–15% above the Japanese price.

7. *Pyrethrum in other countries*—Pyrethrum has been grown in commercial quantities in Algeria, Australia, Brazil, Bulgaria, California (U.S.A.), China, France, Italy, Persia, Spain and Switzerland. But the combined production of all these countries did not exceed 1,500 tons in 1934. In China about 1,500 acres are reported to have been under Pyrethrum in 1942 but the quantity of flowers produced is not known.

8. The following table shows the quantity of Pyrethrum flowers imported into the United States of America from different sources.

Source	In 1934	In 1935
	lbs.	lbs.
Japan	10,094,000	15,203,000
Yugoslavia	299,000	154,000
Italy	113,000	66,000
United Kingdom	42,000	147,000
Russia	38,000	5,000
Brazil	5,000	..
China	..	2,000

9. *Introduction of Pyrethrum into India*—The importance of Pyrethrum not only as a valuable antimalarial insecticide but also as an easy means of keeping the soldiers free from ticks and body lice was first realized during the Burma and Malayan campaigns of the last war. The loss of the Japanese source of supply and the ever increasing demand resulted in an all out effort to find out suitable places to grow Pyrethrum for the Allies. Accordingly experiments were started in several parts of India in 1942 with the seeds obtained from Kenya and after a number of small scale trials it was found that the Nilgiris, having almost the same climatic conditions as in the Kenya highlands, offered an ideal place for the large scale cultivation of Pyrethrum. Large scale plantations were begun in 1943 and an area of 1400·88 acres were planted. In the following year an additional 466·64 acres were brought under Pyrethrum making a total of 1867·52 acres for the Nilgiris. Experiments conducted in the

Upper Palnis (Kodaikanal) which is climatically similar to the Nilgiris, proved that Pyrethrum could be successfully grown in that region also and in 1944 an area of 520 acres were planted with Pyrethrum. In the Nilgiris, a separate Pyrethrum division was created in charge of a District Forest Officer while in the Upper Palnis the plantations were managed by a special Assistant Conservator attached to the District Forest Officer, Mathurai.

II. SILVICULTURAL REQUIREMENTS

10. "*Chrysanthemum cinnerarifolium* is a glaucous perennial 18 to 24 inches high. To the casual observer, Pyrethrum resembles the ordinary field daisy but the two are readily distinguishable. The stems are unbranched and slightly hairy. The leaves are petioled and finely cut. The dried flower heads are hemispherical and consist of a short rounded receptacle, a straw coloured involcure composed of three rows of scales, a disc composed of numerous yellow flowers ; a circle of white or cream coloured ray florets".

Locality factors

11. *Soil*—Pyrethrum is comparatively indifferent to the type of soil on which it grows. In Dalmatia it is grown on rather poor calcareous soils while in Kenya it is grown chiefly in better and acidic soils. In Japan, Pyrethrum grows on barren hilly slopes where the sterile soil is almost totally unsuitable for any other crop. It is important to avoid badly drained localities as Pyrethrum is highly susceptible to water-logging ; soils with a clay pan or murram close to the surface would, therefore, be unsuitable. Very rich forest soils should also be excluded not only because weed growth will be too prolific and will entail high weeding costs, but also because this type of soil often encourages excessive vegetative growth (leaf) to the detriment of flower production. Diseases such as root-rot also seem to be more prevalent on such soils. Generally speaking, loams derived from volcanic rocks, capable of retaining the moisture content during the dry weather are the most suitable.

12. In the Nilgiris and Upper Palnis Pyrethrum has been raised in two types of soils: black loam in which the proportion of clay is slightly higher and a red loam which is lateritic in origin with a pH value varying from 3 to 5·1. The parent rock in both cases is a fine grained gneiss and there is no significant difference in the growth and production of flowers in the two types of soils. In South India, Pyrethrum has been grown in virgin soils, although in Kenya, Dalmatia and Japan virgin soils are strictly avoided on account of the very poor yield during the first year. Some cereal crop such as wheat, rye, barley or oats is grown during the first year and this is followed by Pyrethrum. This practice has given a significantly higher yield, particularly in Kenya.

13. *Altitude*—In South India (latitude 8° to 11° N.) Pyrethrum grows well at elevations varying from 6,000 to 8,000 feet, the best growth being found above 7,000 feet. At lower elevations, although the plant grows, the production of flowers is comparatively very low and it is not, therefore, economical to raise it on a large scale. Experiments to raise Pyrethrum in Mysore and Denkanikotta (elevation 2,700 to 3,300 feet) have shown that although the growth is fair, the yield of dry flowers is as low as 70 pounds as against 300 lbs. per acre per year at higher elevations. Pyrethrum is highly sensitive to frost in its early stages and care should be taken to avoid frosty localities especially at elevations above 7,500 feet. Similarly highly exposed areas are also unsuitable as the cold winds in winter inhibit the growth of the bushes. However, if suitable wind belts are provided, the plants grow very well in such localities.

14. In northern latitudes, Pyrethrum may grow even at lower elevations. The writer has seen Pyrethrum growing very well in Orissa (latitude 23° N.) at an elevation of 3,700 feet.

15. In Kashmir, which is the other place in India where Pyrethrum has been grown on a large scale, the best growth and development are reported to be at elevations varying from 3,500 to 5,000 feet.

16. In Kenya, Pyrethrum is cultivated between 6,000 feet and 8,000 feet, the best growth being seen at 7,500 feet elevation. At lower latitudes – 6,000 feet – the yield is comparatively less being 300 pounds of dry flowers as against 450 pounds at higher altitudes.

17. In Hokkaido, in Japan (latitude 42° to 45° N.) Pyrethrum is largely cultivated at elevations varying from 3,000 to 4,500 feet.

18. *Temperature*—The following table gives the maximum and minimum temperatures of Ootacamund, Wellington and Kodaikanal (Upper Palnis).

Temperature (in Farenheit)

Months	STATION								
	Ootacamund Altitude 7,252 feet			Wellington Altitude 6,200 feet			Kodaikanal Altitude 7,688 feet		
	Mean	Mean maximum	Mean minimum	Mean	Mean maximum	Mean minimum	Mean	Mean maximum	Mean minimum
January ..	54	65	43	55	66	45	52	62	47
February ..	55	67	44	58	70	46	53	64	47
March ..	58	69	48	63	74	53	56	66	50
April	61	71	52	65	76	56	59	68	53
May	61	70	53	66	76	59	61	68	55
June	58	64	52	63	72	58	58	65	53
July	57	62	52	63	71	58	56	62	52
August ..	57	63	52	62	71	57	56	63	52
September ..	57	64	51	62	71	56	56	63	52
October ..	57	64	51	61	68	55	55	62	51
November ..	55	63	48	58	66	53	54	61	49
December ..	54	64	44	56	65	48	53	62	47

19. The mean annual temperature in Hokkaido (Japan) is about 45°F. while in the main island of Honshu the climate is milder with a mean annual temperature of 85°F.

20. *Rainfall*—The following table shows the rainfall of the four stations in South India where Pyrethrum has been successfully grown :—

Rainfall (in inches)

Months	Station			
	Wellington	Ootacamund	Coonoor	Kodaikanal
January	0·8	0·9	3·3	1·9
February	0·3	0·6	2·7	1·4
March	2·0	1·1	2·5	3·0
April	2·9	3·2	4·3	4·9
May	4·1	6·2	4·4	6·2
June	3·6	6·8	3·2	4·1
July	3·2	7·7	3·7	4·3
August	4·0	5·2	3·8	6·6
September	4·7	7·6	5·9	6·8
October	9·8	8·1	13·6	11·3
November	8·5	5·0	12·3	8·3
December	4·1	1·8	6·9	5·1
Year	48·0	54·2	66·6	64·0
No. of rainy days ..	133	96	91	115
Months with less than 2" ..	2	4	Nil	2
Mean annual humidity ..	72	71	..	..

21. Pyrethrum can thrive even with a scanty rainfall as in Hokkaido but its monthly distribution is most important, because Pyrethrum suffers very badly from prolonged drought. Generally speaking, a rainfall of 40 to 45 inches distributed over a period of 10 to 11 months in the year is most desirable. In regions of heavy rainfall the plants suffer very badly from "damping-off" and what is more the soil wash will also be excessive resulting in an appreciable fall in the yield.

III. Planting

22. *Nursery technique*—For a nursery site, it is desirable to select a well drained gentle slope close to a perennial source of water. The ground is thoroughly dug up two or three times to remove all weeds and grasses. Both in the Nilgiris and Upper Palnis, Kikyu grass (*Pennisetum clandestinum*) is a very troublesome weed and particular care is taken to remove all bits of the roots, which if left will sprout up very rapidly. Standard nursery beds of 40 feet in length, 4 feet in width and 3 to 4 inches high, are then formed and 60 to 70 pounds of well decomposed farm-yard manure are mixed thoroughly with the soil. The sides of the beds are protected with brushwood. Paths one foot in width are left between the nursery

beds for watering the beds, removing the weeds, etc. After the beds are formed, they are watered for 3 or 4 days so as to remove any weeds that may be remaining in the soil by allowing them to germinate. Pyrethrum seedlings are highly susceptible to weed competition and before the seeds are sown all the weeds must be removed scrupulously.

23. 3 to 4 ounces of seeds are sown per standard bed. In Japan, the seeds are soaked in cold water and then wrapped in sacking and buried in deep sand for four or five days. In Kenya, no pretreatment of the seed is done before sowing. Pretreatment of the seeds with cold water for a period of 6 to 12 hours has given good results in the Nilgiris, although the results are not significant. After sowing, the seeds are covered with a thin layer of earth and pressed gently ; the beds are then covered with grass laid directly on the soil. In areas where white ant damage is serious, the grass cover is raised a few inches on trellis supported by forked sticks. Grass containing seeds should be strictly avoided as they may germinate and choke the Pyrethrum seedlings quickly. The beds should be watered daily from a very fine rose can. Removing the grass before watering is advisable and the grass may be replaced after watering is done. Germination starts in about 8 days and is complete in about 15 to 21 days. As soon as germination is more or less complete, the grass cover should be removed. The young seedlings are highly susceptible to "damping-off" and if any sign is observed before the germination is complete, the grass cover should then be removed and sunlight allowed to fall directly on the seedlings. In South India, the seeds are usually sown in the month of September or October and the seedlings transplanted in the following April or May. As soon as the seedlings have put forth four or five leaves and if the stand is too thick in the nursery beds, the seedlings should be pricked out carefully and transplanted in vacant beds kept ready for this purpose, at an espacement of 3×3 inches. This will not only prevent "damping-off" in the beds but also produce seedlings of uniform size and good vigour. On an average, one standard bed of 40×4 feet will give 2,500 good seedlings.

24. *Splits versus seedlings*—Pyrethrum is propogated either from whole seedlings or from splits taken from older plants. It cannot be stated definitely which of the two methods is better as each has its own advantages and disadvantages. One significant advantage in planting splits is that they establish themselves much quicker, especially if the planting is followed by a spell of wet weather. If seedlings are used under such conditions, they may be covered with soil and silt washed down from the slopes and have very little chance of establishing themselves. Moreover, splits have the advantage of coming into production earlier than seedlings which results in higher yields during the first year. However, as seedlings are complete plants with an intact root system, they are able to survive much better than splits in dry weather. If splits, are chosen for planting they should be selected bearing in mind the following factors :—

1. Do not select splits from a "blind-bush".
2. Choose only plants with upright well formed stems preferably of a silvery grey colour.
3. Select plants with big flowers and large yellow centres.
4. Only choose plants which are flowering profusely.
5. Splits should not be taken from plants which are more than three years old.

25. *Preparation of land*—As Pyrethrum is a plantation crop and stays in the ground for several years it is desirable to clean the land thoroughly of all weeds particularly grass before planting is done. The land, is therefore, ploughed or forked two or three times and the clods are broken. It should, however, be borne in mind that the soil should not be broken down to a fine tilth because during further operations in the field such as picking, weeding,

etc., the constant trampling of human feet may result in the soil being compacted into a hard mass. Sloping ground is either terraced or graded "contour" trenches are formed at suitable intervals depending upon the slope of the land. In the Nilgiris and Upper Palnis, in addition to graded "contour" trenches, an uncultivated grass belt of 5 to 10 feet in width are left alternating with cultivated strips which are 11 to 30 feet in width to prevent soil wash. The earth in the forked strips are formed into ridges 6 inches high and two and a half feet apart after being allowed to weather for about two months. Seedlings are planted in the ridges so formed.

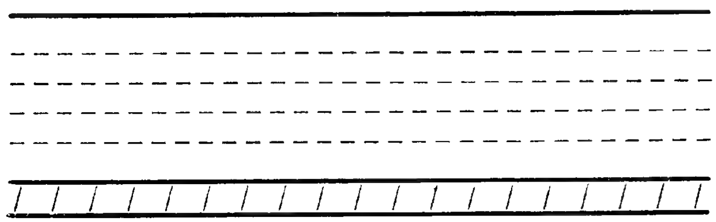
26. *Espacement*—It cannot be stated definitely which espacement is the best as different espacements have been adopted in different countries. In Japan, for instance, the seedlings are planted at an espacement of 7 inches to 12 between plants and 1 foot to 2 feet between rows. In Kenya, espacements varying from 3×3 feet to 3×1 feet and 2×2 feet have been adopted. In the Nilgiris experiments have been conducted with the following espacements :—

(*a*)	2½	feet between rows and	2½	feet in rows.
(*b*)	2½	do.	2	do.
(*c*)	2½	do.	1½	do.
(*d*)	2½	do.	1	do.
(*e*)	2	do.	2½	do.
(*f*)	2	do.	2	do.
(*g*)	2	do.	1½	do.
(*h*)	2	do.	1	do.
(*i*)	1½	do.	2½	do.
(*j*)	1½	do.	2	do.
(*k*)	1½	do.	1½	do.
(*l*)	1½	do.	1	do.

The data collected, when analysed statistically, has shown that treatment (*b*), i.e., 2½ feet between rows and 2 feet in rows, has given significantly the best results. However, in the older plantations started in 1943 and 1944, closer espacement of 1½ feet between plants and 2 to 2½ feet between rows were adopted. With the closer espacements, the disadvantage is that the number of seedlings required per acre is significantly more than with a wider espacement ; for example, with a 3×3 feet espacement the number of seedlings required per acre is 4,840 while with an espacement of 3×1 feet, 14,500 plants are required per acre. Moreover, it has been observed that plants grown too close together do not yield well especially after the second year. From the experience gained in the Nilgiris during the last five years, it may be stated that an average bush grows to a circumference of about two feet and it is, therefore, advisable to plant seedlings at this distance from each other. The 2½ feet width between the rows will not only reduce the nursery and planting costs appreciably, but also enable easier weeding. In slopes and in places where the soil is highly erodible, it is, however, advisable to plant seedlings at a closer espacement in the rows, as this would form a continuous hedge and prevent soil wash. On the whole, each area is to be judged on its own merits and suitable espacement determined.

27. *Time of planting*—In South India, as a result of numerous experiments conducted to determine the best date of planting (plantings were done on the first of every month beginning from April to the following November), it has been found out that April planting immediately after the pre-monsoon showers gives significantly the highest yield per acre.

As a general rule planting should begin when the ground is wet and the weeds have germinated and either removed or harrowed in. On sloping ground the planting lines should follow the contours. The planting lines should be parallel to the top contour so that the short lines end in the lower contour as shown below.



Planting lines.

Grass belt.

As soon as the first pre-monsoon showers are received between April and May, seedlings with at least 8 pairs of leaves are carefully lifted from the nursery beds and taken to the planting area in baskets. It is advisable to examine the seedlings as they are lifted from the beds and to discard those seedlings showing swellings on the roots, as such swellings are characteristic of *Eel-worm* attack. Discarding such affected seedlings will reduce the risk of the pest being transferred to the field. The discarded material should either be buried deep or burnt. Care should be taken to see that the root system suffers from the least possible damage. The planting holes are best made with a pointed stick and they must be dug deep enough to receive the whole root system without the roots being twisted upwards. After the roots have been inserted as straight as possible, the soil must be pressed firmly around them without leaving any air space. If the soil is too wet it should not be pressed too hard as it would form a cake and harden in a dry spell and might lead to the death of the plants. In fact, in very wet weather, it is better to defer the planting for a few days. Deep planting should be avoided as it results in a significantly lower yield. Experiments conducted in the Nilgiris have shown that it is advantageous to cut back newly planted Pyrethrum when about 3 stalks have developed because this encourages the seedling to shoot forth with great vigour. The seedlings should establish themselves under normal climatic conditions in about a month's time. If gaps appear in the lines they should be immediately filled up with either seedlings or splits.

28. *Tending*—Pyrethrum throughout its life-time is highly susceptible to weed competition and the cleaner the field is kept the greater will be the yield. Regular weedings are, therefore, necessary.

29. The common weeds found in the Nilgiris are *Eupatorium glandulosum, Helichrysum* Sp., *Vernonia* Sp., *Hypericum mysorensis, Eulex europeus* and *Cytisus scoparius*. The common grass as already indicated is Kikyu (*Pennisetum clandestinum*). In weeding great care should be taken to see that no disturbance or shock is caused to the root system of the Pyrethrum as the plants suffer very badly from such disturbances. Weeding is best done by hand-pulling at regular intervals and before the plants flower.

30. Normally, in South India, two weedings are done during the year of planting : the first weeding early in July and the second weeding after the South-West monsoon is over – i.e., by September–October. The weeds, after being pulled out, are heaped in the trenches between ridges so as to form a mulch. From the second year onwards, it is necessary to do three weedings a year – the first weeding in July, the second in September or October, and the third in January–February. If found necessary, a fourth weeding may be done by the end of March.

31. In the past, forking the soil between planting lines was done as it was believed that the soil working would encourage the growth of the plants. Subsequent observations

in the field and the reports from Kenya have, however, shown that the root system of Pyrethrum should not in any way be disturbed if the plants are to grow satisfactorily ; the soil working is, therefore, not recommended now.

32. *Manuring*—It has been mentioned earlier that Pyrethrum is quite indifferent to the type of soil on which it grows. In Kenya, it has been estimated that a record crop of 1,000 pounds of dry flowers per acre deprives the soil of only 17 pounds of Nitrogen, 25·75 pounds of Potash and 5·75 pounds of Phosphoric acid. Experiments conducted in the Nilgiris have shown that Pyrethrum does not readily respond to manuring. In Kenya, application of small quantities of phosphates in and around the planting holes is reported to be giving very good results, as it promotes rapid growth in the early stages and enables the seedlings to establish themselves quickly.

33. Putting uprooted weeds between the planting lines to form a mulch is beneficial as it conserves the soil moisture particularly during the dry weather and thereby prolonging flower production right into summer.

IV. UTILIZATION

34. *Picking*—In the Nilgiris, the bushes start flowering in about 6 to 9 months after planting depending on the pre-monsoon showers. If the planting is followed immediately by a dry spell of weather, the plants may take as much as nine months to flower but if in April and May the weather is normal and four or five good showers are obtained, flowering starts even after four months. The yield of flowers during the first year, as indicated earlier, is comparatively low and it may vary from 50 to 100 pounds of fresh flowers per acre. The yield is significantly more during the second year and the peak production is reached during the third and fourth years. Thereafter it falls down.

35. The keeping quality of Pyrethrum flowers and the Pyrethrin content depend entirely on the stage at which the flowers are picked. Immature flowers and over-mature and full blown flowers contain less Pyrethrin and it is, therfore, absolutely necessary to pick the flowers at the correct stage. It is obvious that in practice, flowers could not all be exactly at the same stage of maturity when picked, but care should be taken that all flowers have at least 3 to 4 rows of disc florets open. Men engaged in this work very soon learn to recognize the correct stage at which the flowers are to be picked. From the second year onwards, picking is done at the interval of 7 days in the Nilgiris. In Kenya, the flowers are picked at intervals of 10 to 14 days, in Dalmatia once a week and in Japan at an interval of 14 to 18 days.

36. The flower-heads only are picked from the stalks using the thumb and index finger by a gentle jerk without causing any injury to the plants. Although it is a skilled operation, the boys and girls who are engaged in this work soon learn the technique and they are able to do the work very quickly. The stalks contain comparatively little Pyrethrin and the labour engaged in picking should be instructed not to include any stalks while picking flowers. An average boy in the Nilgiris can pick anything from 25 to 40 pounds per day and an adult may be able to pick 50 to 60 pounds of flowers. The flowers are usually carried in baskets so as to allow aeration. If the flowers are gathered in a closed vessel and compacted, there is the risk of the Pyrethrins getting decomposed due to the heat produced.

37. *Drying*—The flowers may be dried either in the sun or in specially constructed driers, in which hot air is made to circulate at a fixed temperature between trays containing the flowers. Sun drying will usually take about 4 days and is possible only in dry weather and if the acreage is small. During wet weather and if the quantity of flowers picked is large, it is necessary to have kilns for drying.

38. The fresh flowers should be spread out on trays as soon as they are collected to avoid heating and should be put into the drier without any undue delay. It is advisable to have plenty of trays for this purpose. The type of tray used in the Nilgiris consists of a frame 6×3 feet and 3 to 4 inches deep with a wire mesh gauze through which the dried flowers will not pass, at the bottom. Each tray can hold about 30 to 40 pounds of fresh flowers. Drying in a kiln should be done at 130°F. Higher temperatures will lead to decomposition of the Pyrethrin and particular care should be taken to see that the temperature in the drier does not rise above 130°F. A thermometer is kept in the drier for this purpose and readings at regular intervals are taken to ensure proper drying without the risk of the Pyrethrins getting decomposed. In the Nilgiris, a drier can dry 1,000 pounds of fresh flowers at a time in about 8 to 10 hours.

39. *Loss in drying*—In Japan, the loss in weight is estimated to be 65 to 75% and in Kenya it is about 70%. In the Nilgiris, it varies from 72 to 76%. Usually it is reckoned that four pounds of fresh flowers will weigh one pound when dried.

40. After the flowers are thoroughly dried so that they could easily be crumbled between fingers they are packed in gunny bags containing 55 to 60 pounds and despatched to consuming centres. The flowers from the Nilgiris and Upper Palnis are chiefly despatched to the Government Kerala Soap Institute at Calicut for being made into Pyrethrum extract.

41. The dried Pyrethrum may be stored in gunny bags for a period of 3 months without any loss of its Pyrethrin content. Longer periods of storage may result in some loss of the Pyrethrin content. If for some reason the flowers are to be stored for a longer period, they have to be kept in sealed glass jars ; by this method, it is possible to keep the flowers without losing their quality for a period of 5 to 6 years.

42. *Cleaning of bushes*—The dried flower stalks should be regularly cleaned as otherwise the yield has been found to go down appreciably. In South India, these stalks are easily removed by means of a seceuter or a pair of strong scissors. The dry stalks thus removed are kept in the trenches along with the weeds to form a mulch. It is advisable to do such cleaning at least once in two months.

43. *Yield*—The yield has shown very great variations in the Nigiris. The statement below shows the average yield obtained per acre in the Nilgiris between 1943–44 and 48–49.

		Yield of flowers		Yield per acre	
		Fresh	Dry	Fresh	Dry
	acres				
1943–44	1,400	1,038	..	..	..
1944–45	1,400	441,475	107,912	316	77
1945 46	1,800	377,654	96,561	210	54
1946–47	1,800	356,974	89,129	198	50
1947–48	948	120,433	31,113	127	33
1948–49	660	25,540	6,244	39	10

44. Although the average yield is significantly lower than in Japan, Dalmatia and Kenya, it may, however, be mentioned that certain fields have given an yield of 1,700 to 1,900 pounds of fresh flowers during the second, third and greater part of the fourth year of the rotation. The low yield in the Nilgiris can only be attributed to the faulty technique adopted in the past, such as planting on flat ground instead of ridges, improper weeding and regular forking of the soil in between the plants resulting in the soil around the roots being washed away. Experimental plantations adopting improved technique such as ridge planting, careful weeding and preservation of the soil have given an average yield of 1,450 pounds of fresh flowers during the second, third and fourth years. In future plantations, it can, therefore, be safely assumed that an average yield of at least 1,400 pounds of flowers per acre would be obtained.

45. In Japan, the yield varies from 300 to 1,200 pounds of fresh flowers per acre while in Dalmatia it varies from 155 to 800 pounds. In Kenya, where systematic and well planned research is being carried on to improve both the quality and quantity of Pyrethrum, a record yield of 4,000 pounds of fresh flowers has been obtained from certain experimental plantations. The average yield, however, varies from 1,500 to 1,600 pounds per acre. This compares favourably with the yield in the Nilgiris and Upper Palnis.

46. *Pyrethrin content*—The flowers produced in the various fields in the Nilgiris have been analysed by the Research Officer attached to the Medical College, Madras, and the following table shows the Pyrethrin content.

Name of the field	Pyrethrin content (total Pyrethrin)
	%
1. Hecuba	2·24
2. Hodgson's hill	2·49
3. Ree's Corner	2·44
4. Sholur	2·26
5. Muthinad	2·99
6. Brookhampton	2·77
7. Mainalai	1·19
8. Jakundha	1·93
9. Honnatalai	1·81
10. Kodanad	2·20
11. Newman	1·99
12. Tuneri	2·55
13. Honnabetta	1·59
14. Okka betta	2·09
15. Ebbanad	1·43
Average	2·08

47. In Kenya, the average Pyrethrin content is 1·4 and the highest is 2·1. Breeding experiments to evolve a high toxic strain of Pyrethrum were started in several parts of Kenya as early as 1935 and they have already succeeded in producing a strain containing 2·67% of total Pyrethrins. Splits from this improved strain are being planted now to produce it on a large scale.

48. In Japan, the average Pyrethrin content is 0·9 and it varies up to 1·2% while in Dalmatia it varies from 0·7 to 0·8%.

49. *Pyrethrins*—Although Pyrethrum has been known and used as an insecticide for more than 100 years, the active principles in it were not known till 1914. Several attempts were made up to 1910 to isolate the toxic principles in Pyrethrum flowers. Between 1910 and 1916 Staudinger and Ruzicka carried out intensive researches and published a series of papers in 1924 described as one of the finest works in plant Chemistry. As a result of their researches they were able to isolate the toxic principles in Pyrethrum consisting of two organic esters chemically represented by the empirical formulæ

Pyrethrin I .. $C_{21} H_{30} O_3$.
Pyrethrin II .. $C_{22} H_{30} O_5$.

The two compounds are distinct and each has a pronounced insecticidal effect. The ratio of Pyrethrin I to Pyrethrin II in the flower varies between 1 : 0·65 to 1 : 2·42. Pyrethrin I has been found to be slightly more active than Pyrethrin II as it kills roaches in 1 : 10000 solution in 10 to 20 minutes, while the latter takes 20 to 40 minutes at the same dilution. Both the Pyrethrins are highly unsaturated in the acid and alcohol parts of the molecule and, therefore, unstable. Their toxicity has been found to be dependent not only on their composition but also on the spatial arrangement of the molecule and Gandinger considers that the commercial production of synthetic Pyrethrin is highly improbable. Gandinger and Corl ascertained the distribution of Pyrethrins in the different parts of the flowers as follows :—

	Composition of flower by weight	Percentage of total Pyrethrin
Achenes	34·2%	92·4
Receptacles	11·3%	3·5
Involucral scales	11·5%	2·0
Disc florets	25·8%	Trace
Ray florets	17·2%	Trace

50. *Action on insects*—One of the most remarkable features of the Pyrethrins is the rapidity of their action on the insects to which they are toxic. The action of the Pyrethrins on the insects has been described variously by research workers. The concensus of opinion, however, is that they have a direct action on the nervous system. In most species of insects the effect is that of a violent irritation causing paralysis followed by death.

51. *The Advantages of Pyrethrin as an insecticide*—There is no doubt that compared to the various natural and synthetic insecticides available in the world, Pyrethrum is easily the best and most perfect. Its greatest advantage is that in certain concentrations it is transient in its effects. While completely effective against the pests which it is desired to control, after a few hours the Pyrethrins become oxidised and are, therefore, harmless to the useful pollinators and predatory insects. In this respect Pyrethrin has a decided advantage over any other insecticide, particularly D.D.T. which has a residuary effect for a period of 3 to 6

months and along with the harmful insects the useful ones such as the pollinators, predators and parasites that may occasionally visit the plants may also get killed. Secondly, while Pyrethrin is highly toxic to cold blooded animals it is absolutely harmless to warm blooded animals and can, therefore, be used in controlling insect pests that attack food stuffs and household animals such as cattle. The complete control of Grain Weevil, which causes very great damage has been possible with Pyrethrum powders. Similarly in the control of plague and pests in water-works and sewage plants and in anti-malarial control, Pyrethrum has been found as an invaluable insecticide. The control of mosquito larvæ with a spray emulsion containing 4% Pyrethrum extract, 63% of Kerosene, 3% of liquid soap and 30% of water, has been found to be very useful and effective.

52. *Preparation of Pyrethrum extracts*—Both Pyrethrin I and Pyrethrin II are soluble in mineral oils. This property has been taken advantage of in the preparation of the various Pyrethrum extracts. For general purposes Pyrethrum extracts are prepared with refined kerosene oil. Pyrethrum flowers are mascerated with refined kerosene in a tank equipped with an agitator using about one pound of flowers to each gallon of oil. The masceration is prolonged from a few days to several weeks, the longer the better. The mixture is then pumped through a filter press. Extracts containing higher concentration of Pyrethrin may also be prepared by the same process using up to a maximum of four pounds of flowers to one gallon of oil. Horticultural sprays are usually made with alcohol or acetone. Commonly, the Pyrethrum extracts using 10 pounds of dried flowers and 13 gallons of kerosene are prepared for normal household purposes. This extract will contain 0·1% of Pyrethrins which conforms to the normal standard. Such a spray can be used effectively against all usual flying insects such as house-flies, mosquitos, moths and also against cock-roaches, bed-bugs, etc. In Horticultural operations, when a liquid spray is liable to damage the plants an inert powder or filler like Gypsum or Talc is mixed with Pyrethrins dissolved in a volatile oil: for example, an 8% kerosene extract of Pyrethrum containing 2½% of Pyrethrins with 90% Gypsum is mixed in a ball mill to ensure a thorough mixing. Such insecticidal dusts can be sprayed from aeroplanes. In Germany, the dust is used to control the Gypsy-moth in the extensive pine forests. By using suitable sprayers the dust can be sprayed on Coffee and Tea plantations to control the pests. Pyrethrin in the form of keratomised granules has been successfully used for the control of parasites in human beings such as round-worms, tapeworms, etc. Against body lice the alcohol or acetone extract is very effective and head lice are controlled by washing with the kerosene extract of Pyrethrum emulcified with soaps.

53. *Rotation*—In Dalmatia, on well drained hill-sides plants produce for as long as 15 years and in Kenya farmers have reported good results from plantations 8 to 9 years old. The 1943 plantations in the Nilgiris were yielding even in 1948–49 and in certain fields the fall in the yield was not at all appreciable. Generally speaking, there was a significant fall in the yield during the fifth year. It is, therefore, impossible to fix a definite rotation for Pyrethrum as it depends entirely on the locality factors of a particular field or area. However, it is altogether incompatible with good farming to leave Pyrethrun crops in the ground for too long a period and use the same area continuously. Diseases and weeds can only be controlled if a different type of crop is rotated with Pyrethrum. In Kenya, the Pyrethrum is kept for not more than four years and area is then planted with cereals or grass. Pyrethrum followed by wheat is reported to be giving very good results but a grass ley should be included in the rotation as it is only under grass that the soil can recover its crumb structure. This is particularly necessary because the crumb structure of the soil disappears rapidly under Pyrethrum due to the continuous trampling between the lines for picking the flowers, weeding and cleaning. Moreover, in Kenya, it has been found that *Eel-worm* which is a troublesome and serious pest in Pyrethrum plantations cannot be irradicated from the soil without a

period of at least three years under cereals or grass. Taking all these facts into consideration, it has been decided that in the future plantations in the Nilgiris, the rotation will be six years out of which $3\frac{1}{2}$–4 years will be under Pyrethrum and the rest 2–$2\frac{1}{2}$ years under cereals such as wheat, oats, barley, rye or suitable fodder grass.

V. PESTS AND DISEASES

54. Not much attention has been paid to this aspect of Pyrethrum planting in the Nilgiris and very little data is, therefore, available. But in Kenya, considerable amount of work has been done since 1935 and valuable data is available.

55. *Eel-worm*—The most common and troublesome pest of Pyrethrum is the root-knot Eel-worm (*Heterodera marioni*). It is a tiny nematode not visible to the naked eye. But its presence is easily recognized from the nodular swellings on the roots. It lives in the soil and can easily be transferred from one field to another through the affected plants. The extent of damage done by this pest is not known accurately. But it is certain that plants with an affected root system give a significantly lower yield than the healthy plants. No definite cure for Eel-worm has so far been found out in Kenya but it can be completely irradicated by practising a rotation of crops, viz., Pyrethrum followed by cereals or grass and then again Pyrethrum. This rotation of crops is now practised in Kenya.

56. *Root-rot*—This is commonly found in soils that are very rich in organic contents such as forest soils or alluvial loams. Affected plants wilt and die off. Generally plants attacked by Eel-worm lose their vigour and in the second stage they are easily affected and killed by Root-rot. Cutting the affected plants and giving it rest for sometime has been found to give some relief. The best method, however, is to pull out the affected plants so as to prevent the disease from spreading further.

57. *Thrips tabacci*—This is an insect pest which commonly attacks Pyrethrum flowers during prolonged periods of drought. Affected flowers dry up prematurely and turn a brownish colour. By shaking the flower head on the palm of the hand, the small insects will drop out and can be seen by the naked eye. The extent of the damage caused by this insect is not estimated correctly and the damage becomes serious only during periods of prolonged drought or when the plants have been previously weakened by the attack of Eel-worm or Root-rot. Usually at the beginning of the first rains the pest disappears completely. In Kenya, when the attack takes an epidemic form, the plants are sprayed with emulsions of insecticide and the pest is more or less controlled.

58. *Fungi*—Several types of flower diseases have been noticed in Kenya especially in periods of dull cloudy weather. The flower petals may turn brown followed by premature drying of the disc. In other cases the buds may die due to the infection of a fungus belonging to the genus *Alternaria*. This, however, disappears as soon as the weather clears up.

59. Another fungus – *Ramularia* – causes great damage and is assuming serious proportions. The fungus enters the buds or flowers through the bracts on the receptacle, and they turn into a brownish colour. Attacked buds are totally destroyed but if the fungus enters the flowers they may be only partially destroyed. Work on the control of this fungus has been going on in Kenya for a number of years.

60. *Frost and hail*—Severe frost may cause serious damage to the bushes especially in the early stages. In the Nilgiris, the early frost in October causes heavy damage to young plants but the older plants that are more than 2 years old seem to stand the frost well.

61. Hail storms are not of a common occurrence in the Nilgiris and cause only very light damage.

VI. FINANCIAL ASPECT

62. The revenue and expenditure per acre of plantation at the existing level of wages for one rotation is given below :

Expenditure

		Rs.	A.	P.
1.	Nursery costs	40	0	0
2.	Preparation of soil	25	0	0
3.	Planting	15	0	0
4.	1st year weeding	35	0	0
5.	2nd year weeding	35	0	0
6.	3rd year weeding	35	0	0
7.	4th year weeding	15	0	0
8.	Miscellaneous expenditure on staff, buildings, contour trenching and maintenance of boundaries	90	0	0
9.	Picking 3,800 pounds of flowers, drying and despatching 950 pounds of dry flowers obtained at eight annas a pound ..	475	0	0
	TOTAL ..	765	0	0

Revenue

1.	Revenue by the sale of 950 pounds of dry flowers at the existing rate of Rs. 1-8-0 per pound	1,425	0	0
2.	Revenue from 5th and 6th year land lease	120	0	0
	TOTAL ..	1,545	0	0

63. The nett profit is estimated to be Rs. 780 per acre for the full rotation of six years or Rs. 130 per acre per annum. The above estimates are based on an yield of 100 pounds of fresh flowers per acre in the first year, 1,000 pounds in the second year, 1,400 pounds in the 3rd year and 1,300 pounds in the fourth year.

VII. RESEARCH

64. Although the Pyrethrin content of the Nilgiris flowers is the highest in the world, the yield of flowers per acre is miserably low – as against an average of 450 pounds of dry flowers per acre in Kenya, it is only 70 pounds per acre in the Nilgiris. As already mentioned, certain fields have given up to 1,900 pounds of fresh flowers per acre and in the experimental plots an average yield of 1,450 pounds has been obtained. This clearly indicates that a considerable amount of research work has to be done to improve the yield by changing the present technique in planting. In Kenya, a separate Pyrethrum Board has been created and systematic and well planned research into the various aspects of Pyrethrum cultivation has been going on since 1935. They have already succeeded in evolving a strain of both high yielding and high toxicity – an yield of 4,000 pounds of fresh flowers per acre and a Pyrethrin content of 2·67%. Similar research in the Nilgiris is also necessary, if Pyrethrum cultivation has to be taken up seriously.

VIII. CONCLUSION

65. Malaria is one of the worst scourges in India and it has been estimated that on an average a million human lives are lost every year besides sapping the energy of countless number of people. A well-planned anti-malarial control has, therefore, become vitally necessary and the production of Pyrethrum is of primary importance.

66. Besides, the Grain Weevil and other insect pests are causing incalculable damage to our food crops. According to one authority, the Grain Weevil alone is responsible for the loss of more than two million tons of food per annum. The importance of this at the present moment of acute scarcity of all kinds of food can easily be understood and realized.

67. In the Nilgiris and Upper Palnis, almost optimum conditions for the cultivation of Pyrethrum are available and there is no dearth of land. Lastly, the cultivation of Pyrethrum is a profitable occupation.

68. Considering all these facts, the necessity for large scale cultivation of Pyrethrum cannot be over-emphasized.

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PRIVATE FORESTS AND PRIVATE FOREST LEGISLATION

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SUMMARY

The account stresses the unsuitability of the Indian Forest Act of 1927 to cope with the destruction of the private protected forests, and as in Bihar most of the forested areas (some 80 per cent) are under zamindars as opposed to the balance (20 per cent) under Government, it was fitting that this State should be the first to move in the matter of taking them over.

Some differences between the Indian Forest Act on the one hand and the Bihar Private Forests Acts of 1946 and 1947 on the other are shown and then again the differences between the latter, two the first being certified by the Governor and the second passing through the legislature.

The destruction or at least the serious damage wrought to the forests as soon as the application of the Act was sensed in certain quarters, is indicated.

When the Act was first applied, only a certain number of staff to help in the preliminary work of demarcation, was sought and sanctioned. The heavy inroads on the forests in the preliminary stages could not be foreseen, and valuable time was lost in obtaining full control.

The paper states that the work of demarcation is complete, that there has been a beginning at scientific management and the destruction is under control.

Other States contemplating this work would do well to avoid pit-falls of the Private Forest Act and to have a staff adequate to take over from the very beginning.

* * * * *

The history of the Forest Department of Bihar is the history of its attempts to obtain control of all the forests in the State as opposed to the small fraction over which it had control under the Indian Forest Act. A reference to Table II will show that till recently only about 3 per cent of the area of the State was under the intensive forest management.

The position is that out of some 70,000 square miles which comprise the area of the State, 12,000 square miles are under forest. Of the latter, 79 per cent is in possession of zamindars and, therefore, badly managed, and only 21 per cent under the intensive management of the Department. This high percentage of unmanaged forest makes the position of Bihar unique in the country.

Forest Officers here have always been appalled at the insensate destruction of forest growth around them and have realized that such destruction was harmful to them in several respects, the chief of which were (1) the spread of desiccation in the country which has now begun showing its effects on the reserved forests ; and (2) the lack of control on materials similar to those that they themselves were safeguarding with the result that their own materials were being affected.

Forests must be managed by the State and cannot usually be managed by individuals as the policy involved is a long term one. The platitude that forests are required to provide against land-slides, erosion, drought, the sinking of the water level, desiccation on a country-wide scale, and to provide for the interests of the State, need not be repeated here.

Bihar furnishes much of the area forming the catchments of the Damodar, the Brahmini, the Subarnarekha and the Baitarni rivers, the first named now being of world fame with a scheme of the first magnitude to harness its flow of water so as to mitigate damage

from floods in Bengal. The others also go into spate periodically doing immense damage to the countries nearest their mouths.

The spread of desiccation in this country need not be stressed either. The history of every State in the Union shows how forest growth has disappeared in it and what the effects of this are on climate and vegetation. In our district of Ranchi for instance 120 years ago the climate during the year was moist enough even in the warm weather to enable Tea to be planted : but now with the general hot and dry conditions from March to May, the area under tea is gradually shrinking ; replacements are made but at great expense and trouble ; and tea planters have had to alter their times of pruning to offset the very dry conditions in the prolonged hot weather that have set in. The Pear too used to be cultivated on the Ranchi Plateau but the trees have almost disappeared and efforts now made to spread the species, are unsuccessful. Numerous other instances of this deterioration could be given but one more very striking one is the presence of very large trees in sacred groves relics of the ancient forest, that are scattered throughout aboriginal country and of the depauperated forms of the same species of subsequent origin growing in their vicinity.

So in 1906, 1916, 1918 and 1926 repeated efforts were made to cause the zamindar's areas to be placed under intensive forest management. One of the attempts went so far as to apply the Indian Forest Act to certain zamindari areas and to declare the zamindar's staff as full powered Forest Officers. Needless to say that these days for such staff soon ended by reason of their various misdemeanours ; the measure had to be withdrawn. Then a scheme to acquire zamindari forests was mooted, but in a legislature dominated by landlords, this did not materialize.

It is true that the Indian Forest Act provided a method of taking over the management of zamindari forests but under it the zamindar had first to be told that he was mismanaging them and had to be given a chance of explaining and remedying matters. Then, when Government assumed management, only the following acts were prohibited :—

(i) the breaking up or the clearing of land for cultivation.

(ii) the pasturing of cattle.

(iii) the firing and clearing of vegetation.

Such acts were banned only when there was fear of storms and avalanches, or to protect the soil, or to prevent land-slips, erosion, sand deposits, the formation of ravines and torrents, or to maintain the water supply in springs, rivers and tanks, or to protect roads, bridges and railways and other lines of communication or to preserve public health.

A bad point in the application of this part of the Indian Forest Act was that if the zamindar wished, he could force acquisition by Government after a lapse of three years or before the expiry of twelve years of the taking of these measures.

With rents varying between annas 4 and Rs. 1-4-0 per acre the costs of acquisition would amount to between three and twelve thousand rupees per square mile. If we realize that our best divisions in their best days give a profit of only Rs. 15 per square mile, the folly of acquisition proceedings may be gauged. So sections 35 to 37 of the Act were virtually a dead letter.

It was possible to get control of private forests under section 38 of the Indian Forest Act, but this section presupposed the zamindars' requesting that their forests be taken over ; however in 1931 it was decided to find ways and means to apply it.

The difficult and delicate task of getting the zamindars to offer their forests fell to the lot firstly of the late Mr. Sabharwal and then of Mr. Sharma, both of the Indian Forest Service

and results show how creditably they have acquitted themselves of it. Intensive propaganda was made and several zamindars, many of the more knowledgeable ones, made their forests over to management. But still the response was not large enough and did not emanate from many of those from whom it was most desirable. Only 838 square miles of a possible 12,000 were thus obtained. The basis of the forest work was an agreement between the Government and the zamindars; among other things it enjoined on the Government the production of annual accounts to the zamindars by the Forest Department.

Other features were the employment of local villagers as forest guards who were given jagir lands by the zamindars in part payment of their salaries : this was done to reduce costs of management. This *prima facie* desirable feature had undesirable repercussions. it virtually entailed that such persons could not be transferred (very often the Forest guard identified himself with the local populace rather than with the management), and that they were not entirely under the control of the forest officers. As such jagir lands had to be cultivated by the persons concerned, time which should have been spent by the forest guards on duty was devoted to cultivation.

The agreement also did not provide for the very large increase in the cost of living and with the effects of the war there was a virtual stalemate in certain respects.

There were other adverse features but to describe them would be out of place here and would entail a lengthy exposition so only two or three might be mentioned in brief. The zamindar had had to bear all the preliminary costs of demarcation of the forests and of their settlement. As certain forests were not worth acquiring they entailed a heavy cost to the zamindar and were perpetual burden to the Government.

A feature of the agreement was that the Government would retain the management for forty years only and on annual rental of -/1/- and -/1/6 per acre would be paid to the zamindar which would later be set off against any profits that might accrue.

Another important feature of some of the agreements was that half the profits of management would be paid to the landlords, the calculation of such profits including proportionate costs of the Government staff involved but not the pay and travelling allowance of the Divisional Forest Officer. Zamindars, therefore, did not come forward with the alacrity forecast and as said before only a small fraction of the existing zamindari forests were managed scientifically. These forests lay scattered among others that were uncontrolled ; the adverse effect of this has been mentioned earlier.

Government, therefore, decided that a completely different Forest Act was necessary, an Act which gave no option to the zamindar.

So the position in 1939 was that some 2 per cent of the State was under good forest management, perhaps another 15 per cent covered with forest, but under indifferent or pernicious management, section 38 applying to some 838 square miles out of a possible 12,000 square miles. The Chota Nagpur Private Forest Bill sponsored by ardent and far seeing members of the Legislative Assembly was on the anvil, when the Second Great War broke out.

These members resigned but the same bill was the basis of the Bihar Private Forests Act of 1946 and the latter was certified by the Governor. As its name implied it was applicable to the whole of the Province as against merely a part of it.

This Act was a considerable improvement on the Indian Forest Act in most respects. Government could take over any forest that was recorded as such in the previous settlement operations. Under it the zamindar was given an annual rental of anna 1 to $1\frac{1}{2}$ per acre and the net profits of management.

Very shortly after this Act came into force its defects revealed themselves. Such a sweeping measure *prima facie* adverse to the interests of so many and so influential a section of the people, had defects but pardonable defects to which reference will be made later.

This Act, a Section 93 one, lapsed on 31st March, 1948 but its successor the Bihar Private Forest Act, 1947, was enacted by legislature and received the assent of His Excellency the Governor of Bihar on the 15th February, 1948.

Between these two Private Protected Forests Acts there were some important differences the chief of which was that under the later Act very early in the proceedings of notifying the forests they were made over completely to the care of the Forest Officers pending demarcation, settlement, enquiry of rights, etc. Under the former Act, the early stages of action took the forests over from the zamindars but virtually did not allow the forest officer to do anything other than demarcate them. The necessity of the forest officers taking charge completely and immediately need not be stressed. Illicit fellings had to be controlled, the spread of cultivation checked, the continuance of the leases given by the zamindars and the control of the produce under transport had to be attended to, and produce had to be distributed to right-holders and grantees.

How the working of these measures was all but frustrated must now be explained.

When the Acts were to be enforced, it was contemplated that certain selected and compact areas of good forests only would be taken up for management but as soon as the first was mooted there was a heavy exploitation and occupation of many forest areas which will be described later. This could not be foreseen. Previous experience of demarcation under the Indian Forest Act did not include widespread acts of cutting and lawlessness. The preliminary staff proposed and sanctioned was meant to help in demarcating the areas and so policing work was impossible.

Government, therefore, could not wait to select these areas ; they were scattered over 10 districts and then they did the only thing possible and that was to bring the legislation to bear on all the lands recorded as forest in the previous settlement. But unfortunately Government were not prepared to take over even partial management at that moment ; there was no staff or very little staff to try and control the destruction that was being daily wrought. As an instance of unpreparedness in a certain division there were only 60 forest guards appointed originally to deal with the forests coming under the Act. This number had to be increased from time to time until now the number stands at over 300. Similarly with the reminder of the staff : their increase was only gradual. For example four extra-ranges were started for the private forests work in one division, whilst at the present day there are twelve extra and even these will have to be subdivided in time. The expansion of the staff was lamentably defective both as regards time and numbers.

The sudden application of the provisions of the Forest Act, the time lag between its provisions and the fact that the staff was adequate neither in quality nor in number to take over the work of management immediately the first provisions of the Act, were issued, prompted and allowed much damage to the forest – not permanent damage it is true, but still damage enough to upset forest officers who could do little more than wait till they could take suitable action in the matter.

Certain districts in this province had been settled about thirty years previously, and in the interval the lands had changed ownership several times perhaps by sale or by inheritance and in many, perhaps in the majority of cases, such change had not been recorded. A preliminary provision of the Act, was that each zamindar should be notified individually and by name – and it was a difficult matter to notify each one individually as they would evade notice.

Without such notifying, there was a delay in the application of the subsequent provisions of the Act. This difficulty was eventually countered but then there was unfortunate delay.

Then again, part of the proceedings was to notify the plot number of every piece of land to be taken over as forest. But plots of land which were recorded as forest thirty years previously had long since been turned over to cultivation ; such change had not been recorded in the documents of the collector's office, and, therefore, there was much arduous and unnecessary clerical work done in this respect and much time was thereby lost.

The magnitude of the task cannot possibly be gauged even from the knowledge that certain districts had more than 2,000 square miles of forests, had sometimes 1,600 villages and had perhaps 5,000 zamindars to be dealt with. Each of the provisions of the Act was time absorbing in application and on account of the legal nature each had to be meticulously applied as well. There were 10 districts involved, the records of 17,331 villages to be consulted and the inspection and demarcation of 12,000 square miles to be done. All this had to be done by a staff already working full time and trying to make up the arrears which had arisen during the war – and their original area was only 2,000 square miles.

When the Private Forests Act was enforced, the second Great War had just concluded. The forests had been heavily worked to supply the exigencies of war, and heavy exploitation continued as a country-wide dearth of forest products existed. The zamindars and the purchasers vied among themselves to sell and buy forests. This they did to forestall the provisions of the Act. The zamindars realized that with the passing of the Act, they would be unable to sell their forests, and the purchasers lured by attractive rates for forest produce and by provisions of the Act that enjoined compensation to those holding contracts, continued purchasing them ; so their sales did not cease for a moment, and widespread devastation of the forests continued. The results can be better imagined than described. The Forest Department was unable to prove a single ante-dote in the numerous contracts made just at the time.

Mention must be made here of the methods adopted to defeat the Act.

There were four classes of people concerned with the forest :—

(1) The zamindar who owned them.
(2) The contractors who took forest leases from them.
(3) The agriculturists who took cultivating leases from them.
(4) The right-holders and the grantees.

As stated earlier a long time before the first Act (of 1946) was passed, all these people knew of its imminence and set to work to derive what advantage they could from the state of affairs. Zamindars knew they were about to lose their hold on their forests and so leased them out to persons under categories (2) and (3) for ready cash.

Those under category (2) were sufficiently shrewd to realize that compensation would have to be paid them at the high prices which were prevailing for all forms of forest products. The war had ended but there was a heavy demand for them. The local agriculturists swarmed into the areas clearing forests for cultivation and to obtain a right if possible on the areas, and then the right-holders and the grantees thinking the forests were to be reserved, immediately laid themselves out to cut as much as they could.

Added to this, certain land-holders in order to embarrass Government handed over their forests to the local people as a free gift. This they did to set the people against the Government and to gain the good graces of the former. Needless to say this act resulted in damage to the forests. There were several acts of allied nature everywhere, and there were numerous assults on the staff.

Agitators placed all this damage at the door of the Forest Act and not at that of the mischievous people who should have known better. They exploited the situation and the results of the working of this Act were far different to what was visualized by those who were responsible for this very wholesome measure.

The Act itself had provided for procedure that was suitable in normal times ; it allowed a period between the application of the various sections so that those concerned could file their objections, which could be heard and appealed against if necessary. After its several stages, the Act placed the forests under the management of the Forest Department which should have been ready to take proper control. But these were not normal times, and the provisions of the Act should have been such as to obtain immediate and complete control : one of the features of the latter being heavy penalties to miscreants.

As stated elsewhere the work of notifying involved delving into the records of the Collectorate, the recruitment of innumerable *amins*, their training and supervision, the collation of their work and the rigid procedure of passing the resultant records to Government through the Settlement Officers. And all this had to be done for ten district at the same time. The work was one of the first magnitude, and if it be remembered that when ordinary settlement work is done in a district, it takes roughly three years of hard labour with a band of innumerable amins and concomitant staff to finalize matters, the achievement of the Forest Department in this State can well be appreciated. This work fell to the smallest cadre of Forest Officers of any State in India and yet in the space of four years, they have almost completed the demarcation. In addition to this they have laid out coupes so that right-holders and others may obtain their requirements, and have brought a useful system of management to bear on the forests.

The moral of this exposition is that in view of the prevailing conditions if any Government propose applying a Forest Act to new areas, most certainly a new Act as opposed to the Indian Forest Act, will be necessary, and under it, it should be possible to take complete possession of the forests immediately. Further, that Government should have the staff ready, trained and standing by to take over complete control if the forests are to be saved from this temporary but severe set back experienced in Bihar.

TABLE I

European countries.—Percentage of total land under forest

(Deduced from the Memoranda of Central Board of Forestry, 1951)

Country	Forest areas as percentage of total land areas	Country	Forest areas as percentage of total land areas
Austria	38·1	Rumania	22·0
Belgium	18·2	Russia	45·0
Czechoslavakia	32·9	Spain	9·7
Denmark	9·3	Sweden	51·4
Finland	64·4	Switzerland	22·0
France	19·00	Yugoslavia	32·7
Germany (excluding Austria)	26·8	OTHER COUNTRIES	
Greece	18·5	North America	33·3
Great Britain	5·0	Central and South America	38·9
Hungary	10·3	Middle-East and North Africa	3·4
Italy	18·7	South-East Asia	23·0
Netherlands	6·1	Pacific Area	6·3
Norway	23·8	Africa (excluding North Africa)	22·1
Poland	22·7	World	27·6
Portugal	25·8		

TABLE II

Forest area 1947–48 except for Bihar which shows the latest figures

(Memoranda Central Board of Forestry, 1951)

States	Total land area	State forests	Forests owned by corporate bodies	Private forests	Total forest area	Percentage of forest area in the State
1	2	3	4	5	6	7
	Square miles					
1. Ajmer ..	2,367	73	230	290	503	·25
2. Andamans ..	2,500	2,500	..	..	2,500	100
3. Assam ..	51,521	21,268	52	317	21,637	41
4. Bihar ..	69,745	2,062 (2·9%)	..	6,820 (9·8%)	8,882	12·7
5. Bombay ..	76,026	12,696	3	169	12,870	17
6. Coorg ..	1,582	834	..	331	1,165	74
7. Madhya Pradesh	98,573	19,422	..	21,493	40,915	42
8. Madras ..	1,25,163	18,816	..	14,871	33,687	27
9. Orissa ..	32,695	2,874	..	1,678	4,552	14
10. Punjab (I) ..	36,020	3,878	..	..	3,878	11
11. Uttar Pradesh ..	1,06,248	14,275	21	3,076	17,372	16
12. West Bengal ..	28,215	2,652	..	1,632	4,284	15
Total ..	6,30,655	1,01,350	308	51,733	1,53,391	24

The following comments are offered on the position in Bihar :—

(1) There should be three times the present area under forest management if the recommendations of Central Board of Forestry are to be implemented.

(2) That if the 40 millions of people inhabiting Bihar were to rely on firewood for domestic purposes and to use half a seer of firewood per day drawn only from the forests, some 6,000 square miles of fully stocked quality A Sal coppice Forest is required.

Similarly, to provide 2 cubic feet of house building timber per year for each person, 3,750 square miles of good quality forest would be required.

The inadequacy of the position is apparent.

TABLE III

Percentage of Private Forests to Total Area of Forests

(Deduced from Memoranda Central Board of Forestry, 1951)

1.	Ajmer	48·9
2.	The Andamans	..
3.	Assam	1·5
4.	Bihar	79·0
5.	Bombay	1·32
6.	Coorg	28·5
7.	Madhya Pradesh	52·5
8.	Madras	44·5
9.	Orissa	37·0
10.	Punjab	..
11.	Uttar Pradesh	17·6
12.	West Bengal	38·2

TABLE IV

Area of Private Protected Forests in Bihar

Division	Total area of the district	Area demarcated (In square miles)
Monghyr	3,975 square miles	677 (Monghyr and Bhagalpur)
Bhagalpur	4,248 " "	
Ranchi	7,159 " "	903
Manbhum	4,131 " "	460
Giridih	..	738
Hazaribagh	7,016 " "	2,018 (Hazaribagh, Gaya and Patna)
Gaya	4,766 " "	
Patna	2,164 " "	
Palamau	4,901 " "	1,708
Santal Parganas	5,480 " "	202
Porahat	3,905 " (Singhbhum) (Porahat and Dhalbhum)	114
Dhalbhum		
10 districts	47,745 Square miles	6,820

(1) Total area of Bihar State is .. .. 69,745 square miles

(2) Total area of Forests under Intensive Management .. .. 2,062 " "

(3) Total area now under the Private Forests Act .. .. 6,820 " "

TABLE V

Statement of increase owing to the taking over the Private Protected Forests in Bihar

(I) STAFF

		1945	1951
1.	Number of Circles	1	2
2.	Number of Divisions	8	16
3.	Number of Gazetted Officers	15	35
4.	Number of Rangers	19	• 72
5.	Number of Deputy Rangers and Foresters	94	351
6.	Number of Forest Guards	334	2,148

(II) EXPENDITURE

	1945–46	1946–47	1947–48	1948–49	1949–50	1950–51
1	2	3	4	5	6	7
	Rs.	Rs.	Rs.	Rs.	Rs.	Rs.
1. Total Expenditure (*less* item 2)	10,78,365	16,50,965	23,72,523	31,04,067	39,62,509	45,77,611
2. Expenditure on R-Loans and Advances (i.e., Demarcation of Private Forests) ..	55,392	62,926	3,74,195	10,93,118	13,54,078	9,63,636

SAL (*SHOREA ROBUSTA*) IN SOUTH BASTAR FOREST DIVISION, M.P.

BY C. E. HEWETSON, I.F.S.
Conservator of Forests, Madhya Pradesh

The South-westerly limit of natural Sal in Central India is close to the Indravati river at about 19° N. and 81° 20′ E. Dr. Mooney in paper (1) had suggested that Sal in this part of India had not reached its natural limit and was capable of spreading further South and South-West. This year I had time to visit this tract of country and to see the forests at the present limit, and also some interesting outlying patches of Sal which according to local village tradition were planted by village headmen (*Majhi*) (see the map).

2. The first thing to notice is that up to the present limit of natural Sal, the trees are of the highest quality. Plate I shews the largest Sal yet found, and perhaps one of the largest Sal trees now living in India. It stands on an island in a *Nala* which flows into the Indravati near Barsur. The girth is 16′ 10″ and the height is estimated to be 134′. The bole is sound and cylindrical. There is no bulge at breast height ; Plate II shews an untouched piece of Sal forest in almost uninhabited country about 10 miles North of the large tree. This was on gentle slopes at the base of a hill range and well away from any permanent water. Trees 7–10 feet girth are quite common in this locality. It is hoped to get this area made a Reserved Forest. This picture does convey an impression of the healthiness and maturity of the association. It is obviously the climax forest for the locality.

3. Dr. Mooney suggests that Sal is prevented from spreading and the range is in fact contracting due to human interference and Plate III shews what the local Maria Gond does to the fine climax forest shewn in Plate II. Plate III was taken only a few miles away in a similar site. The saddest thing is not that the Sal forest is destroyed, but that the soil which can support such magnificent forest can hardly give for two or three years even the most miserable agricultural crop. This is the worst type of *Soil-mining* and in Milue's memorable phrase, the period of "profitable sin" is hardly one crop.

4. The next point is to examine the evidence for the theory that Sal could grow for a considerable distance further South. The Divisional Forest Officer, Shri K. Y. Rao has reported three out-liers of Sal. The villagers all give the story that seed was brought and sown by a village headman. Presumably the motive was to obtain the seed which was one of the few sources of oil, 200–300 years ago.

The first area is near Nalesinar on the South bank of the Indravati and about 9–10 miles from the nearest natural Sal to-day. This is about 150 acres and contains trees over 6 feet girth. It is reported that 200 large trees were felled some years back for the palace of the Zamindar of Kutroo. The area covered by Sal is roughly rectangular and Sal seedlings are found up to 200 yards from the main block. Plate IV shews the boundary stone of the "Plantation" according to local tradition. The plantation must have been made 150–200 years ago. The two men are standing by the nearest Sal tree. The second area is the more interesting. It stands in an old deserted village Karka on a foot-path from Hiroli Forest Village to Loa beneath the Western wall of the Bailladilla mountain. The nearest Sal to the North is 35–40 miles and to the East the Bailladilla mountain 4,500 feet effectually cuts off any plant migration. This group consists of a sole ancestor 8 feet girth and 103 feet high surrounded by a second generation about two to four foot girth and poles and seedlings. The group is only about 2–3 acres. Estimating the age of the ancestor at 150–200 years it is seen the Sal does not spread rapidly, but it is obviously at home. Plate V shews the ancestor at left centre

background with members of the second generation in the right foreground and back. The natural regeneration of Sal is profuse inside the colony but only scattered in the surrounding miscellaneous forest. In this case spread to the East is locally stopped by bamboo brake (*Oxytenanthera nigrociliata*) along a water course with permanent water.

The third area (not seen by me) is to the South-East corner of Bailladilla towards the Aranpur pass. In this case the Sal is growing inside the village itself.

5. To round off the enquiry it would be satisfactory, if we could, by the examination of the soils outside the present natural Sal forest and to the South and South-West decide whether they are suitable for Sal or have the structure and characteristics required to support a Sal forest, but our knowledge does not yet extend so far.

It may be permitted, however, to throw out a suggestion that an established pure crop of Sal has a perceptible influence on the Soil and may, anyhow for a time, bring the Soil into a condition highly suitable for Sal regeneration. We may also hazard a guess that in time the soil may become unsuitable and natural regeneration fail to appear. I hope I have written enough to shew that an examination of the soils along the boundary may lead to an advance in our understanding of the ecology of Sal.

(1) *Reference*—A note on the Southern Limit of the Sal (*Shorea robusta*) in Orissa and Bastar State Indian Ecologist Vol. 2. H. F. Mooney.

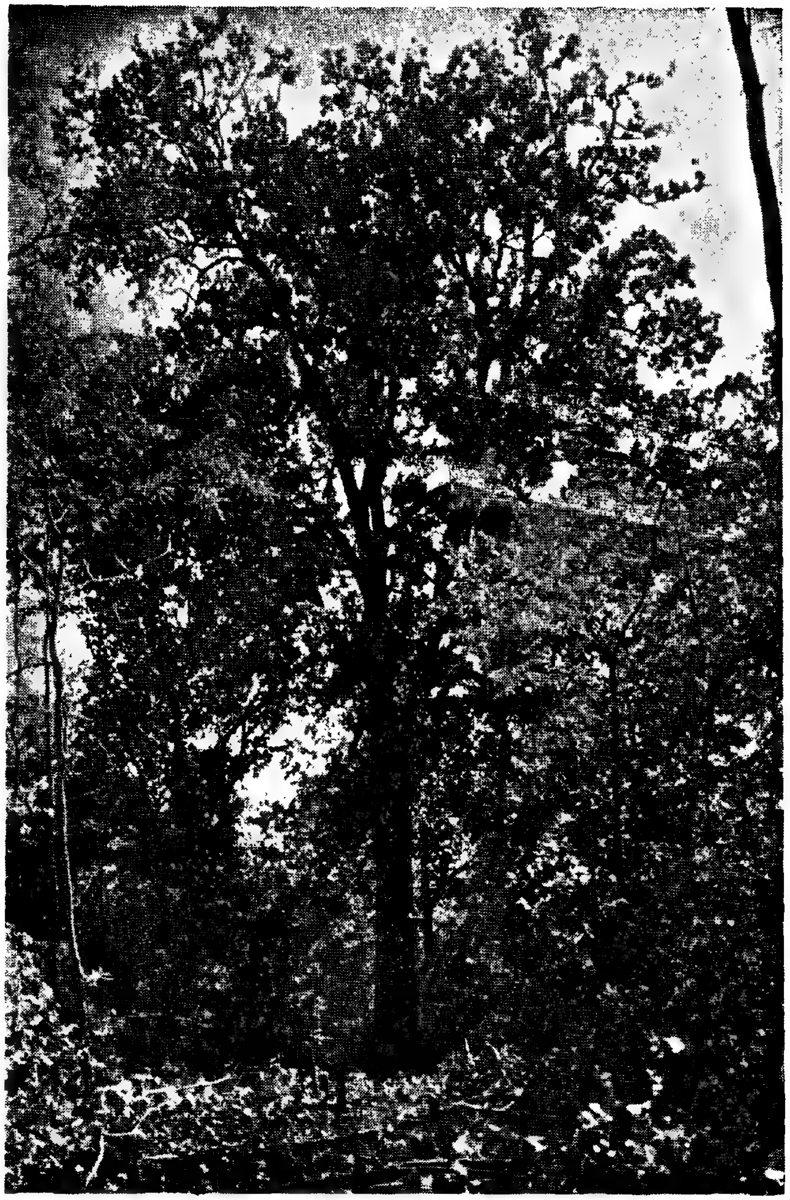


PLATE I.—*Shorea robusta* (Sal) 16′–10″ girth, 134 feet high, Mangheer, near Barsar, South Bastar.

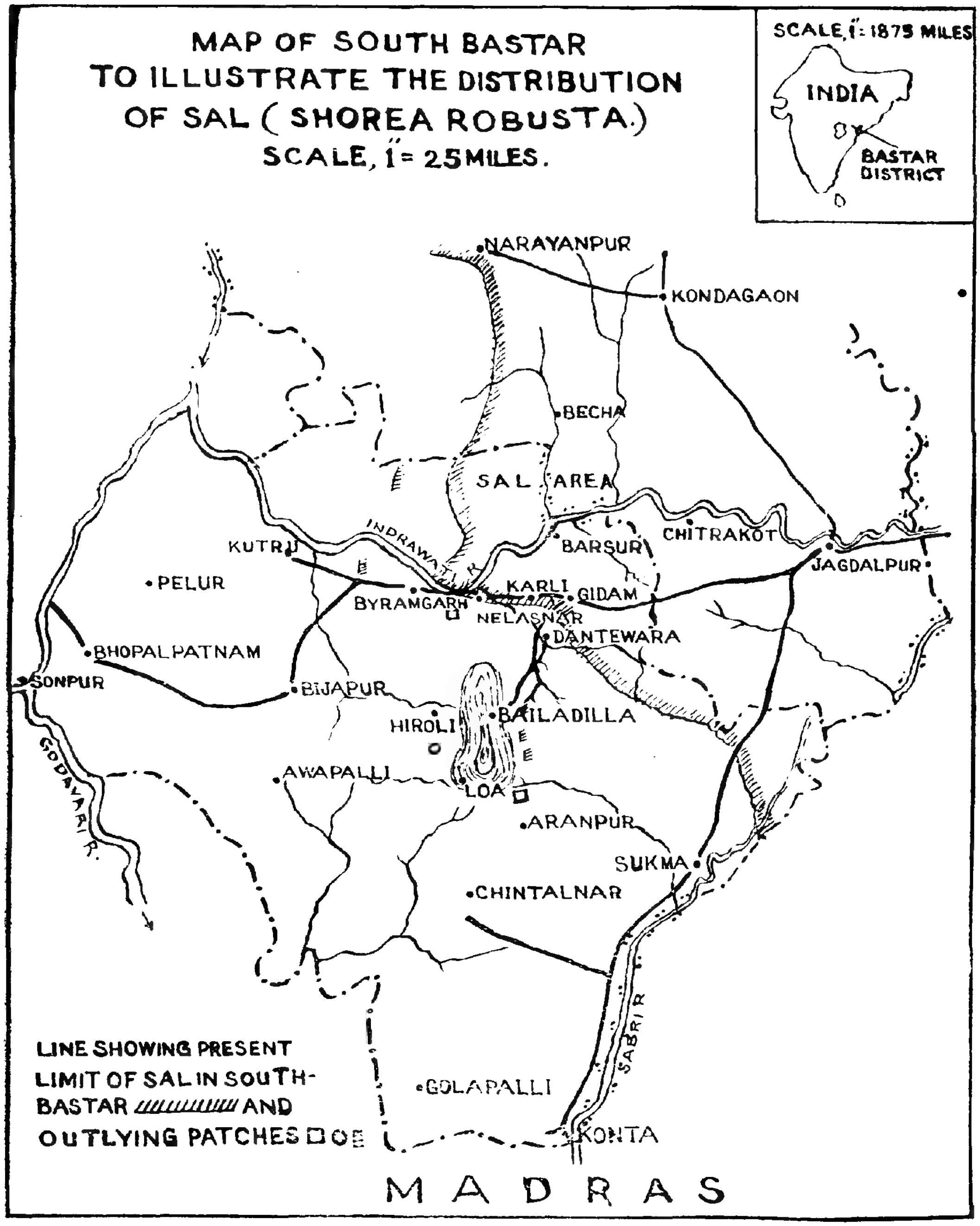
PLATE II. Mature climax sal forest, near Becha, Bastar, M.P.
Photo by C. E. H.

PLATE III. Sal cemetry, Kosalnar, South Bastar.
Photo by C. E. H.

PLATE IV.—Boundary stone "plantation" Nalesinar, South Bastar.
Photo by C. E. H.

PLATE V. -Lone ancestor sal with progeny, Karka, Bijapur, South Bastar.

Photo by C. E. H.


MAP OF SOUTH BASTAR
TO ILLUSTRATE THE DISTRIBUTION
OF SAL (SHOREA ROBUSTA.)
SCALE, 1" = 25 MILES.
SCALE, 1" = 1875 MILES
INDIA
BASTAR DISTRICT
NARAYANPUR
KONDAGAON
BECHA
SAL AREA
INDRAWATI R.
KUTRU
BARSUR
CHITRAKOT
JAGDALPUR
PELUR
BYRAMGARH
KARLI
GIDAM
NELASNAR
DANTEWARA
BHOPALPATNAM
SONPUR
BIJAPUR
HIROLI
BAILADILLA
GODAVARI R.
AWAPALLI
LOA
ARANPUR
SUKMA
CHINTALNAR
SABRI R.
LINE SHOWING PRESENT LIMIT OF SAL IN SOUTH-BASTAR AND OUTLYING PATCHES
GOLAPALLI
KONTA
MADRAS

THE UTILIZATION OF FOREST AND OTHER WOOD WASTES

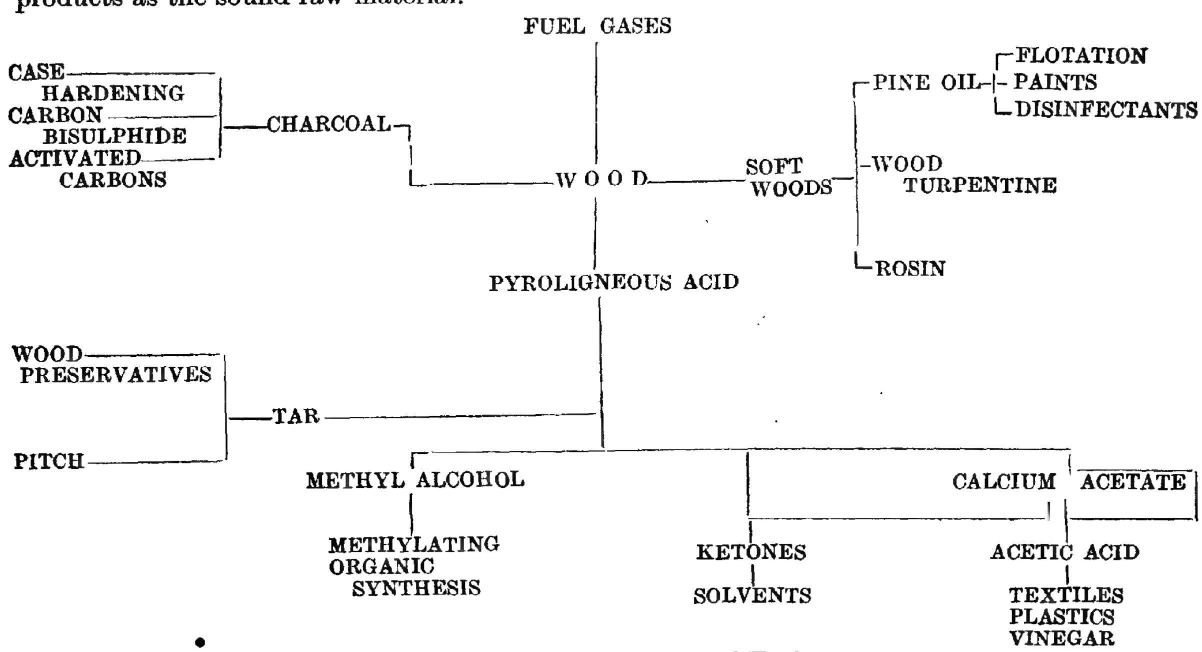
BY K. S. MEYER*

SUMMARY

The occurrence of forest wastes and their influence on the timber industry are discussed. The disposal of the wastes by means of chemical methods to produce charcoal and its by-products are described, and the industrial uses for these products are given. Industrial and economical points to be considered before establishing a wood distillation plant are also given.

The economic disposal of defective and waste timber is of utmost importance to the timber industry everywhere, but particularly to countries where these wastes are large in proportion to sound, saleable timber. In those countries, the timber industry will experience difficulty in developing on a balanced and economic footing, if a heavy loss on the wastes has to be offset by higher prices on the sound, good quality timber. There are also vast areas of woodlands in many tropical and Eastern countries, which are unproductive at present because of the low quality of the timber for which there is no market. To these countries, the economic disposal of the wastes followed by reafforestation could bring great wealth of benefit to the whole community.

Because of their defectiveness from the physical and mechanical point of view, the utilization of these wastes, which includes such ligneous grasses as bamboo, lies in the chemical field. Even pulping for paper and boards should be excluded, as these products can be produced economically only from raw materials yielding approximately 45 per cent of mechanically sound fibres. This is a percentage which would not be obtained from forest wastes. The chemical utilization of these wastes – through destructive distillation – offers the great advantage that slightly decomposed and decaying material yields practically the same quantities of products as the sound raw material.



Products of the Distillation of Wood.

* Manager of Tintern Wood Products Ltd. Formerly Chemist of Wood Distillation (England) Ltd.

The Chemical Conversion of Wastes -The manufacture of charcoal only, which constitutes a simple and partial form of wood distillation, has been practised for many centuries. The commercial recovery of the by-products of the manufacture of charcoal dates back only to the end of the last century, and much progress was made, after F. H. Meyer introduced the semi-continuous horizontal car retort, and an improved system of by-product recovery.

Briefly – all such natural products as wood, bamboo, ligneous grasses, and coconut shells when subjected to temperatures up to 400° C. in a steel retort or kiln, will decompose into charcoal, and in addition form methyl alcohol, acetic acid, acetone, tar and quantities of less than 1 per cent of a large number of other compounds including ; guiacol, furfural, and phenols. Inflammable gases having a high heating value are also given off during the reaction. From resinous woods, the by-products of distillation contain up to 2 cwt. of the valuable rosin tar from which turpentine is produced.

For most of the normal wastes, the approximate yields on destructive distillation per ton of raw material are : 20–25 per cent charcoal, 3 gallons wood alcohol containing 15 per cent methyl acetate – 10 per cent acetone – 75 per cent methyl alcohol, 0·7 cwt. pure acetic acid, and 5 per cent wood tar.

During the last fifty years, different types of wood distillation have been developed, all with the aim of making the process continuous to achieve a greater output per retort and economies in the cost of fuel per ton of charcoal produced. From the industrialist's point of view, simplicity and trouble free operation of the plant, combined with low running and maintenance costs are equally important considerations, and for this reason the horizontal car retort of 5 to 10 tons capacity*, developed from the early Meyer retort, is so popular with many operators. This type of retort produces up to 2·5 tons of charcoal per day, can be operated by unskilled labour, and has to be closed down only three times a year for the cleaning of the flues.

The recovery of the by-products is carried out in steam heated stills equipped with fractionating columns. Although the total quantity of by-products amounts to not more than 15 gallons per ton of wood, this small quantity has to be extracted from nearly 150 gallons of pyroligneous acid (the name given to the condensable vapours leaving the retort during the distillation process).

An interesting development in wood distillation plant is a portable retort having a capacity for two tons of wood, and equipped for collecting the by-products which are then sent to a central plant for further refining. This system promises to be a big advance in wood distillation technique, as it makes possible the conversion of the wastes on the spot without incurring unnecessary transport and handling costs.

The Industrial Uses of Charcoal and its By-Products—The uses of charcoal vary form one country to another. Where there is a shortage of coal and coke, and cheap charcoal is available, it is used as a metallurgical fuel for the smelting of iron and other ores in the manufacture of the respective metals, and also as a domestic fuel. Charcoal preparations are also used extensively for providing the hard surfaces (Case Hardening) required for machine tools in the engineering industry.

In the chemical industry, carbon bisulphide used for the manufacture of viscose rayon, is made from charcoal. The by-products of wood distillation are used principally as lacquer solvents, and also in the textile and plastics industries ; whilst wood alcohol has been used as a motor fuel from time to time. A secure market exists in many countries for the range of

* A number of retorts of this type made by Messrs Blair, Campbell and McClean have proved very successful.

liquid by-products having a boiling point 75–90° C. where the regulations regarding the methylating of alcohol stipulate that the oils used for this purpose have to be the products of the distillation of wood.

Recently, the successful manufacture of calcium carbide, using charcoal, was reported, from which the compound acetylene is made. It was this gas, which formed one of the key stones of the German synthetic chemical industry during the Second World War.

Considerations Regarding the Establishment of a Wood Distillation Plant—The manufacture of charcoal and its chemical by-products should only be considered in the following circumstances :—

(1) If the raw material is available in plentiful supply, and at very low cost.

(2) Where water is available close to the place of distillation.

(3) Where rail or other cheap transport is readily accessible, or where a consuming industry is close at hand.

(4) In countries short of coal, or possessing a steel, textile, and general chemical industry.

Where these conditions appertain, a distillation plant is a sound investment, and a most valuable asset not only for the timber industry but for the industry in general of the country concerned in view of the wide range of products required by so many of its trades, which can be readily and economically obtained by the destructive distillation of forest and other wastes.

RECOMMENDATIONS OF THE *AD HOC* COMMITTEE APPOINTED BY THE GOVERNMENT OF INDIA, ON THE IMMOBILIZATION OF RAJPUTANA DESERT

The Government of India appointed an *ad hoc* Committee consisting of the following members to consider the problems relating to the immobilization of Rajputana desert and to make suitable recommendations.

Shri M. D. Chaturvedi, I.F.S., Inspector-General of Forests – (*President*).

Shri C. R. Ranganathan, I.F.S., President, Forest Research Institute.

Shri R. N. Singh, I.F.S., Chief Conservator of Forests, Uttar Pradesh.

Shri C. M. Chowdhuri, I.F.S., Chief Conservator of Forests, Rajasthan.

Dr. B. Pal, Director, Indian Agricultural Research Institute, New Delhi.

Shri J. Banerji, I.F.S., Deputy Inspector-General of Forests – (*Secretary*).

Shri D. D. Saigal, I.F.S., Officer on Special Duty, Central Water and Power Commission, New Delhi.

Shri V. S. Krishnaswamy, I.F.S., Central Silviculturist, Forest Research Institute.

Shri G. S. Lamba, Officer on Special Duty, Rajasthan Afforestation Scheme.

The Committee toured extensively in Rajasthan Desert between the 10th and the 22nd of February, 1952 and after a close examination of the problem on the spot, it made detailed recommendations unanimously. Unfortunately Dr. Pal and Shri J. Banerji, Secretary, could not undertake the tour and the President appointed Shri V. S. Krishnaswamy to act as the Secretary of the Committee during the tour.

As the recommendations of the Committee will be of interest to our readers, we have great pleasure in reproducing them below.

I. A Desert Afforestation Research Station under the aegis of the Forest Research Institute, Dehra Dun, should be set up at Jodhpur to study, *inter alia* –

(*a*) the silviculture of various species growing already in the desert, with particular reference to their succession in the saline drifts, sandy soils and mountainous tracts ; the influence of biotic factors on their development, and methods of propagation and establishment ;

(*b*) the possibilities of introducing exotic desert species from other countries, and from other parts of India, such as *Prosopis juliflora*, *Agave* spp., etc.

(*c*) the edaphic factors, especially air borne salt contents and the effect of minute traces of salt in freshly deposited sands on moisture retentivity ;

(*d*) the hydrological conditions by collection of water level data of wells through the existing revenue and other governmental agencies with particular reference to their brackish nature. A qualitative appraisal of the degree of brackishness would suffice. Advantage should be taken of the data collected by the Survey of India, the Central Water and Power Commission, and the Rajasthan Underground Water Board ;

(*e*) the rainfall by setting up rain gauges, where necessary, at *tehsils*, *thanas*, grass farms and Special Police outposts ;

(*f*) wind velocities at selected points and the nature of aeolian deposits. Advantage should be taken of the organization of the Meteorological Department in Rajasthan for this purpose.

The Desert Station will also maintain a large seed store for the distribution, free of cost, of seeds of various species, carefully cleaned and packed, through departmental agencies, to be sown broadcast at the break of rains. The species selected should be those which are comparatively immune from browsing. Seeds of species susceptible to browsing should be distributed only to such organizations as can secure a certain measure of protection.

II. In addition to conducting research as broadly outlined above, the Officer-in-Charge of the Station will arrange for demonstration of desert control methods by—

(*a*) organizing the creation of oases of vegetation around :—

(i) Rajasthan Armed Constabulary Posts ;

(ii) Railway Stations ;

(iii) Police Stations ;

(iv) *Tehsils ;*

(v) Schools.

(*b*) creating a 5-mile wide forest belt to withstand the onslaught of blown sands from Sind ; the belt should be located about 5 miles inwards of the western border of Rajasthan. This would require complete elimination of sheep, goats, camels and cattle from the belt and may involve acquisition of land. The length of the belt would be approximately 400 miles and its afforestation should be completed in 10 years.

(*c*) establishing shelter belts along selected roads and railway lines running transversely to the direction of winds ;

(*d*) running a large nursery at Jodhpur for experimentation and distribution of plants ;

(*e*) conducting a wide publicity campaign through such agencies as the Rajasthan Government may direct, indicating

(i) improved methods of lopping of *Prosopis spicigera* with a view to minimizing damage ;

(ii) the harmful effect of allowing cultivation on sand dunes ;

(iii) the advantage of growing a belt of trees on the windward side of each field ;

(iv) correct agricultural practices ;

(*f*) taking over 6 blocks of not less than a thousand acres each distributed on :—

(i) freshly deposited sands (e.g., Rural University at Sardarshahr) ;

(ii) older sand deposits ;

(iii) mountainous tracts (e.g., near Jodhpur on the Shergarh road),

in order to ascertain the best methods of afforesting them with a view to providing grazing, fuel and small timber for the surrounding population. These areas should, if necessary, be acquired. It would, however, be convenient to take over *Khalsa* waste lands for the purpose. As far as possible large areas capable of demonstrating rotational grazing should be selected. For ensuring frequent inspections such blocks should be easily accessible.

III. Advantage should be taken of the Ford Foundation Trust or of the Technical Co-operation Assistance Plan for establishing a centre in a suitable locality to demonstrate correct land use, rotational grazing, fixation of sand dunes, cattle breeding, etc., on the lines of the Etawah Project.

IV. The attention of the Rajasthan Government should be invited to the pressing need for :—

(1) increasing the proportion of the area under forest in Rajasthan in general and in the desert zone in the Bikaner and Jodhpur civil divisions in particular. The existing overall proportion of forest in Rajasthan is far from satisfactory, being :

	Sq. miles
Land area ..	.. 1,31,000 approx.
Forest area ..	.. 13,000 approx.

or 10% approximately. The desert region has, however, less than 1% under forest. The forest area can be increased by reserving large blocks of waste lands for the creation of forests to supply more particularly the needs for fuel of large villages and towns. In this connection mention may be made of the recent abolition of the Jagirdari system which renders it possible to undertake large scale reservation for the purpose at little cost. Considering the difficult conditions obtaining in the desert zone, the proportion of forest to be aimed at should be at least 50% ;

(2) the adoption of improved agricultural practices and creation of wind belts on cultivators' fields, which should be encouraged by granting concessions in the land rental realized from the tenants concerned, as was the practice in some of the States before integration ;

(3) taking steps to create subsidiary forest belts, more particularly between the outer desert zone and the inner arid zone as follows :—

(i) Railway belts (*a*) Ganganagar–Loharu–Narnaul.
(*b*) Raniwara–Samdhari–Ajmer.

(ii) Protection belt – Balatra to Nagaur ;

(4) the establishment of seed stores at suitable centres of the Rajasthan Forest Department.

V. It is understood that the Central Water and Power Commission is also proposing to set up a research centre in Rajasthan for the study of geophysical, hydrological and other factors. The closest co-ordination should be secured between the Desert Research Station and the Centre proposed by the Commission. Detailed hydrological studies as recommended above may, with advantage, be entrusted to the centre proposed to be set up by the Commission.

ECONOMICS OF SHIFTING CULTIVATION IN SOUTH KONKAN*

BY S. A. SHAH, B.F.S.
Assistant Silviculturist, State of Bombay

SUMMARY

Practice of shifting cultivation as obtaining in South Konkan is described ; points of difference between it and similar practices elsewhere are brought out. The evil effects of this practice are described in brief. The dependence of local populace on it is dealt with at length; in short, it represents the soul and the local populace, the body. This is the main reason why this pernicious practice is followed even after realization by the persons concerned that it is not the most economic method of utilizing the hills which are worth many times more. Principles governing a balanced land-use in this region are given and the solution is suggested.

Introduction—Shifting Cultivation is the oldest method of cultivation, the world over, occasioned by the nomadic mode of life led by the people then. It is, however, curious and anomalous too that though the ever-wandering people of South Konkan have changed their habits and have now settled down in colonies leading a social life, the practice has persisted to the great damage of the society ; habits die hard indeed ! It is not so only in Konkan but I fear, a repetition of the same is to be found in other states and Unions of States as well. (I shall be very glad to hear about them).

It should not be understood that it is only a question of habit with the Konkanis that can be changed by propaganda, persuasion or failing that by legislation and prosecution and the shifting cultivators be made to confine themselves to permanently cultivated plots only. The pernicious practice of shifting cultivation as is practised in Konkan where it is known as "Kumla or Kumbla" is something more than a habit, religious prejudice or a tribal matter. It is in this respect that it materially differs from similar practices obtaining elsewhere. It is, therefore, necessary that various aspects of it be studied thoroughly in order to be able to devise ways to convert this harmful practice into a beneficial one. Any hurried measure divorced from a thorough appreciation of local factors would do more harm than good and would, for ever (almost) shut off doors of a possible solution later on. It is, therefore, herein after attempted to analyse the facts that have been gathered and to trace out the root cause of the harmful practice a remedy for which would incidentally cure the various external symptoms as evidenced in wide-spread erosion, falling fertility of soil, general water shortage as a result of gradual lowering of water-table and a host of others.

Physiography of South Konkan—A few lines about the relief of the tract dealt with is considered necessary to make more intelligible that what follows. South Konkan is all hilly ; the main range of Western Ghats constitutes its eastern boundary, its projections and outliers at times discontinuous, running right up to the coast in the west. Both the height and steepness fall off as the sea is approached. As a consequence, therefore, the region is traversed by numerous small streams ultimately combining to create rivers which were once navigable several miles inland. A casual look at the topographical map of the District would, I am sure, give an idea of the degree of ruggedness of the region.

Shifting Cultivation – its causes—The foregoing description of the District would theoretically merit it to be a predominantly forest district with a limited area confined to valleys

* Southern Division of Ratnagiri Collectorate.

and lower reaches of hills with easy gradients, under cultivation or actually fit for cultivation. The reader would be surprised to learn that there is practically no forest area to speak of. The District is managed entirely as an Agricultural District, there being no industries worthy of any mention. The communications are very poor and there are no railways. With a limited area fit for cultivation and with an absolute absence of industries, the population density is expected to be low on theoretical considerations. But, this tract provides an illustration par excellence that theory does not always lead to a correct appraisal of problems. The population density varies from 200 near the Eastern boundary to 450 per square mile near the coast. I cannot conceive of any other region with a similar physiography having a population density anywhere near to this. By all standards, this represents a density which the area under cultivation in this hilly area cannot support. Also, as pointed out before, there are no industries as well to absorb excess population. In order to support such an out of proportion population agriculture has found unbridled extension into unsuitable areas including seemingly inaccessible slopes of the Western Ghats. It is only too well known that the hills cannot be cultivated for any length of time with the result that the cultivation has to shift from place to place. This in brief, represents the genesis of shifting cultivation. A peculiar feature probably not shared by similar practices in other districts is that the shifting cultivators over here have a small holding lower down for permanent cultivation.

Economics of shifting cultivation—Shifting cultivation which is synonymous with "Bush-fallowing" is practised extensively including apparently inaccessible precipices where there is some soil for the inferior millets to take root in. At present, cultivation is done generally for one year but only in exceptional cases where the fertility of soil is good and pressure on land is great that the area is cultivated for two years consecutively. However, I am inclined to think that a majority of the area is incapable of yielding two crops consecutively in view of a prolonged abuse with loss of fertility. When the population was sparse, period of fallowing was long enough to allow the depleted soils to recuperate and consequently the soil was fertile. But with increased population, the period of fallowing is reduced to provide larger area annually. Thus, it appears that two opposing factors though interdependent, viz., increasing population demanding a shorter rotation to provide larger areas for cropping and the reduced fertility requiring a longer period of fallowing necessary for the restoration of fertility have to be reconciled. This is, thus, a vicious circle out of which there appears no escape at present.

The vicious circle alluded to above has perhaps no parallel elsewhere. The tribal people who practise shifting cultivation elsewhere are so few and the forest area available is so large that the idea of loss of fertility and erosion never crossed the mind of anybody. That this is the state of affairs is confirmed by Mr. J. P. Mills, C.I.E., I.C.S., the great expert in the administration of the tribal areas of Assam who has stated this in unequivocal terms ; thus, "Areas are known in Assam, where the same hill-sides have been Jhumed (meaning cultivated periodically) for hundreds of years, without apparently losing any of their fertility". Mr. W. V. Grigson, I.C.S., holds similar view in respect of shifting cultivation (bewar) in Madhya Pradesh.

The rotation as followed in South Konkan varies from 7 to 10 years but has now a tendency to increase progressively on account of a gradual but accumulative fall in soil fertility. After clear-felling the area, which is quite a tough job and takes a pretty long time, whatever firewood is required is removed and the debris then set fire to. Slight hoeing with a spade may be done or may be done away with. After one or two good showers, inferior millet (*Nachani*) is then broadcast and then the area is left to itself except for one or two occasional visits to see that weeds are kept away (there are not many weeds to be taken care of after a good initial burn) and to reap the final harvest. The harvest is done after paddy grown on their permanent

holdings is harvested. Thus, it will be seen that the cultivation of inferior millets on hills does not interfere with paddy cultivation. Also, there is practically no Rabi Crop and hence the villagers can afford to devote fair weather for clearing the jungle growth.

If all the above operations are converted into value equivalents, it would be found that in the long run it is most uneconomical, apart from several other indirect disadvantages, for the shifting cultivators to cultivate the hills. A very rough calculation for one acre of cultivation on the hills is given below :—

I.	*Clearing of Jungle-growth :*		
	It would require two men to work for at least one and a half months.		
	The daily wages during fair season in the locality under reference may be taken as Rs. 1-4-0 approximately		Rs. 113
II.	*Slight hoeing with a spade :*		
	Two men can complete this work in about two days ..		Rs. 5
III.	Cost of seeds		Rs. 2
IV.	*Harvesting :*		
	Two men may require four days to complete the work ..		Rs. 10
		Total	Rs. 130

Note.—This does not include the rent to be given to the owner.

As against this, the value of *Nachani* that he harvests works out to about rupees ninety only. Thus the cultivator is at a net financial loss of rupees forty. This revelation should not lead the reader to believe that the shifting cultivator is a bad economist. He is not ; he is a practical economist, as will be seen later on.

Cultivation of hills is done once in about ten years meaning that in the intervening period no revenue accrues except for occasional firewood and grass. If this very area were to be planted up with *Anacardium occidentale*, at a very conservative estimate, an average income of rupees seven hundred per annum would accrue from fruits alone in addition to fire wood once in 30 to 40 years. This will be a continuous income except for about 4 to 5 years following the year of plantation as against a net loss of Rs. 40 once in ten years and no revenue at all in the rest of the period. If, however, the same area is put under timber trees for which the soil, climate and topography are ideally suited, the cultivator would derive several times as much as he gets under cultivating the hills. Added to this, several indirect advantages resulting from conservation of soil and moisture would work a great deal in maintaining and improving the factors of locality of the region.

Discussion in the foregoing paragraphs leaves an impression that the shifting cultivator is a very bad economist. Hardest of all the realists as a cultivator is, and one of the most practical class of people as he represents, it is illogical to believe that he has not realized it. His is practical economics. Force of circumstances and practical considerations very vital to his life have influenced him in resorting to shifting cultivation on hills in preference to any other more economic use.

He realizes that if he were not to undertake cultivation of hills, he will have to starve because he would not get work anywhere else to engage himself in ; he would, therefore, be forced to be idle. Even more important than this is that he would not be able to purchase imported *Nachani* for, he has not got the purchasing capacity for it and *Nachani* is a complementary food without which he cannot live. *Nachani* has to be provided somehow or

other if the local population is to subsist. Area really fit for cultivation is much less than that required to meet the local requirements and all this area is fit for paddy only ; *Nachani* cannot be grown there as a Kharif Crop. *Nachani* has assumed added importance in the present days of rationing because the quota of rations is not adequate for them ; hence it serves as a supplementary food also. All these considerations make it abundantly clear that cultivation of hills is the very life-blood of the local populace. Their dislocation from the hills would be identical with the removal of their souls from their bodies. Shifting cultivation represents the very foundation on which rests the village economy and any attempt to effect its complete prohibition cannot but result in mass unrest and chaos.

I have been, so far looking upon shifting cultivation as unessential and hence could be done away with completely by persuading the tribal people to settle down to permanent cultivation. But what has been observed in South Konkan demonstrates clearly that shifting cultivation is essential at least in that region and that it is intimately bound up with the rural economy. Thus, the foregoing study of the economics of shifting cultivation has yielded very interesting results the knowledge of which is a necessary pre-requisite for any officer engaged in the preparation of a forest development scheme.

Adverse effects of Shifting Cultivation—Not without reason, the pernicious practice of shifting cultivation has far reaching influences, inter-alia, on the hydrological regime, soil fertility and timber and firewood resources of the region. For a region endowed with 80 inches to over 150 inches of annual precipitation to experience water-shortage from March till the break of rains is something difficult to appreciate. Annual precipitation with the exception of a negligible proportion rushes back to the sea whence it came. Floods have been, of late, more frequent and more violent not because there has been an increase in the amount of rain-fall but on account of an increased run-off, mainly. Adverse effects of floods on cultivated fields nearby, lines of communication, life and property, etc., are too well known to need any description. Another adverse influence is the gradual decrease in the perennial section of rivers and streams with the consequence that the area under irrigation is dwindling down progressively. Of course, statistics are not available to confirm this but it is as true as truth can be. The creeks and rivers have silted up to an amazing degree ; Kharepatan and Rajapur, well-known Bunders have now become ports of the past. Timber and firewood resources of the district have now been threatened with a shortage. Looking to the present condition of the hills, one wonders whence did large sized timber that went to support ship-building yards in Malwan and Vengurla come ? How could Arabs purchase large sized timber from Kharepatan and Rajapur ? Where from did people bring large sized beams and logs that are built luxuriously into their houses and temples ? It has now to be told to a visitor that all this was produced locally.

The manner in which the area is clear-felled and subsequently burnt preparatory to cultivation is very injurious to tree-growth. Trees are cut high and naturally, therefore, coppice resulting from this is very weak. Added to this is the damage from subsequent burn which is generally very heavy. With periodic clear-fellings and burnings, natural regeneration is completely excluded and the coppice progressively weakened and hence reduced. During the interval between two croppings the trees are profusely lopped for rabbing. The cumulative effect of all this has been that less hardy species disappear first and then do the more hardy ones. The retrogression stages of this area makes an interesting study. Though the various retrogression stages in different localities of South Konkan vary not within wide limits, the ultimate sub-climax stage is invariably the same. The penultimate stage where grasses predominate and tree-species are totally exterminated, persists for a very long time. I was taken by surprise to find *Euphorbia nerifolia* (?) and *Calotropis procera* in Ghonsari where average annual rainfall is in the neighbourhood of 120 inches. Existence of these two shrubs is

not difficult to account for, because with grasses comes in heavy grazing. The forests are now to be found predominantly deciduous where but a few evergreens are to be encountered.

The problem and its solution—The problem in its ultimate analysis is one of over population leading to an ill-balanced land-use in order to sustain it. Ill-balanced land-use has ruined the country-side and is mainly responsible for an appallingly low standard of living. The hills which were potentially highly productive once have not been harnessed to the full and in the best possible manner with the result that it would now take several years before the original productive capacity could be completely restored. Also, during the process of the restoration as envisaged above, great restraint will be required on the part of the local populace and it is doubtful whether it will be willingly forthcoming. But, it has to be done if a greater disaster is to be averted.

The most efficient management of land is that under which it "produces the most and deteriorates the least". This particular kind of land management is governed by climate, soil and topography. If this is departed from and the land resources managed solely for the satisfaction of our immediate needs, then disaster alone would result. In South Konkan, the physical factors demand that at least 60% of the area be managed as forests for a balanced land-use. As against this, there is not even one per cent. Such a overwhelming disregard for Nature can wrought only ruin and nothing else. That hilly areas should have at least 60% of their land area under forests finds a place in the new Forest Policy of Government of India declared very recently. It is, therefore, obvious that no permanent good can be achieved unless this condition is satisfied.

Destructive forces of shifting cultivation can be converted into creative powers under the well known method of Taungya. As pointed out and emphasized in the foregoing sections, it would be unwise to stop shifting cultivation altogether even though most desirable at the present juncture. Hence, the only probable solution is the introduction of the well known methods of Agri-silviculture though this method, too, would call for some restraint on the part of the local populace, but, this they have to do if they do not want to die. All the local conditions are conducive to the successful implementation of Agri-silviculture.

At present, a cultivation cycle of about ten years is followed. It is impossible to grow mature forest trees in such a short period ; nor is this period adequate enough for the soils to recuperate depleted fertility. This period, therefore, shall have to be enhanced. Such a measure would result in the curtailment of the area available for cropping. This cannot be helped in the beginning. Later on, when the areas have improved probably after one complete rotation of 40 years, it may be possible to crop the same area in two consecutive years so that it would have the effect of actually halving the rotation. The balance of deficit can be safely expected to be met by enhanced fertility and more area being cropped under irrigation with improved hydrological conditions. In the beginning, it is not advisable to fix a rotation longer than 40 years firstly because the area is impoverished to such an extent that uneconomic increment is likely to be put on by the crop after an age of 40 years and secondly because a longer rotation would curtail the area available for cropping to an extent which would arouse the public against the Department. It is under these circumstances that a rotation of 40 years is provisionally fixed though a longer rotation of 60 years or even more would be necessary after the expiry of this rotation. The material produced in the rotation of 40 years would be large enough to command a ready market both locally and in Kolhapur.

Conclusion—Land is a national asset in addition to being a private property, yielding handsome income in perpetuity if scientifically managed, thus contributing its mite to the growth and prosperity of a Nation. If ill-managed, it may spell ruin both to the owner and to

the neighbouring area connected with it. It is precisely for these reasons that Government cannot remain a mute spectator and ignore the misdoings of a land-owner. It is only Government who is competent and capable to deal with the problems of land-management. It has, accordingly been proposed to acquire 25,000 acres of these hills to start with and thus open up avenue for future extension in the right direction. In a balanced land-use lies the salvation of a country !

Any measure calculated to prohibit shifting cultivation would spell disaster and ruin the rural economy of the region. The dependence of the local populace on the hills is so great that depriving them of these hills would mean starving them. Hence, the only alternative is to regulate it in the best possible manner so that the freedom of the local populace is interfered with as little as possible. This can be done only by combining a shorter rotation with Agri-silviculture.

REFERENCES

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ARTEMISIA IN GARHWAL

BY M. GUPTA, A.I.F.C., P.F.S.
Divisional Forest Officer, Garhwal Forest Division

A note on the "Estimation of Santonin in Artemisia species" published in *Indian Forester* for September, 1951 and from a perusal of the famous book "Indigenous drugs of India", by Col. R. N. Chopra, it appears that it is probably not well known that this costly medicine grows wild in considerable quantities in the Kumaon hills particularly in Garhwal. The species is locally known as *Purcha* and is particularly found in the Niti valley in the basin of Dhauli river. The elevations at which it is generally found range anything from 10,000 to 12,000 feet. Shri J. D. Khanduri, Range Officer, Pindar Range while incharge of Chamoli Range reported abundant growth of this species, which is probably *Artemisia maritima*, near Jhelum and Kego villages on both sides of the Dhauli river.

It appears that due to Garhwal being inaccessible, the occurrence of this species was not known and no efforts to collect and exploit it for extraction of Santonin alkaloid were ever made. As the medicine is very expensive one (prices are reported to range anything from Rs. 400 to Rs. 800 a lb.) and has become all the more important because of the partition of India and Kashmir *artemisia* being in the zone at present occupied by the Pakistan troops, it would be certainly worth while examining several samples of this plant with a view to determine the alkaloid content therein. Even if the percentage is low, the high cost and the present shortage of the extract may make the exploitation of this species economically feasible. Besides the cost of the dry crude medicine is not likely to be higher than Rs. 30–40 per maund at Kotdwara railhead (E.I.R.).

With this object in view, it appears that a sample of *Artemisia maritima* was sent to the Forest Research Institute, Dehra Dun. The method and the time of collection of this species are so important because of the variation of the alkaloid content in different months of the year, as well as in the various parts of the plant and also at the various stages of its growth that it is very necessary that the persons collecting the samples, often no more than a Forest Guard, should have clear and detailed instructions about them. The sample most probably collected by wrong methods and at the wrong time was not found quite up to the mark in its Santonin content.

It is now proposed to send a few samples again in the different months, and containing only those parts as are rich in content (e.g., the stem has little or none). Chopra in his 'Indigenous drugs of India' suggests to strip off the leaves and flower buds directly from the plant by hand and then dry them in the sun. This leaves the plant to put on fresh growth and the method is not wasteful. At the same time, the stalks are excluded, which would otherwise lower the percentage content of the alkaloid.

The result of the investigation would be watched with interest as on their success would depend the solution of a great problem of feeding the new hungry santonin-factories of India. The large quantities of *Artemisia* available may enable the Indian masses to get the medicine at a cheap price. Besides this, the species can be easily and successfully cultivated in the *bugials* where *kuth* had been cultivated in the past. Due to dying out of the demand for *kuth* at present, the areas are lying idle.

Incidentally, besides being useful in expelling intestinal worms, and as a stomachic it is also used as heart and respiratory stimulant. It is also used for dropsy and as an anthelmintic.

STATEMENT OF ACCOUNTS OF THE *INDIAN FORESTER* FOR THE YEAR 1951

Item No.	RECEIPTS	Amount	Amount
		Rs. a. p.	Rs. a. p.
1	Opening balance as on 1-1-1951 :—		
	(i) Face value of investments in custody with the Allahabad Bank Ltd., Dehra Dun as under :		
	3% Conversion Loan, 1946 ..	18,300 0 0	
	Stock Certificates of 1946 ..	1,400 0 0	
	3% 2nd Victory Loan, 1959/61 ..	3,900 0 0	
	3% F.D. Loan, 1970/75 ..	6,000 0 0	
	P.O 5-year Cash Certificates ..	10,000 0 0	
	P.O. 10-year Defence Saving Certificates ..	2,500 0 0	42,100 0 0
	(ii) Cash with Allahabad Bank Ltd., as per Pass Book	8,415 1 8	
	Less cheques issued during Dec. 1950 but encashed in January, 1951 ..	−2,105 0 0	6,310 1 8
	(iii) Cheques, etc., in hand not deposited during 1950 ..		3,834 12 0
	(iv) Cash in hand		2,521 11 3
2	Subscriptions received during the year :		
	(i) For 1951 ..	13,414 9 0	
	(ii) For 1948–49 ..	201 4 0	
	(iii) For 1950 ..	254 7 0	
	(iv) Advance for 1952–53 ..	1,807 5 0	15,677 9 0
3	Sale proceeds of stray issues of old and new copies and volumes of *Indian Forester*		409 3 6
4	Advertisements		2,843 14 0
5	Sale of reprints of articles ..		187 5 0
6	Interest on loans and deposits	996 12 0	
	Interest on 5-year Cash Certificates of Rs. 10,000 encashed on 26–6–51 ..	1,796 14 0	2,793 10 0
7	Receipts from miscellaneous sources ..		496 11 0
	TOTAL .. Rs.		77,174 13 5

Item No.	EXPENDITURE	Amount	Amount
		Rs. a. p.	Rs. a. p.
1	Establishment charges		2,245 4 6
2	Fees and allowances, etc. ..		60 0 0
3	Printing Charges of *Indian Forester* :		
	(i) 1951 issues ..	11,918 1 10	
	(ii) 1949 and 50 issues	15,334 13 2	27,252 15 0
4	Cost of paper :		
	(i) for printing ..	2,661 10 6	
	(ii) for illustrations, etc.	2,167 4 3	4,828 14 9
5	Cost of half-tones and line blocks ..		1,835 11 3
6	Stationery and printing ..		379 6 0
7	Postage and telegrams		1,053 9 0
8	Bank charges		220 6 6
9	Income-tax and surcharge ..		232 5 0
10	Refund of subscriptions ..		100 13 0
11	Cost of store articles, their maintenance and repairs		2 0 0
12	Miscellaneous charges including freight, conveyance, binding and packing, etc.		239 6 6
13	Balance carried over on 31–12–51 :—		
	(i) Face value of investments in custody with the Allahabad Bank Ltd., Dehra Dun :		
	3% Conversion Loan, 1946 ..	18,300 0 0	
	Stock Certificates of 1946 ..	1,400 0 0	
	3% 2nd Victory Loan 1959/61 ..	3,900 0 0	
	3% F.D. Loan, 1970/75 ..	6,000 0 0	
	P.O. 10-year Defence Saving Certificates ..	2,500 0 0	32,100 0 0
	(ii) Cash with Allahabad Bank Ltd., Dehra Dun, as per Pass Book..		6,216 15 5
	(iii) Cash in hand as per main cash book	352 0 0	
	Cash in hand as per imprest cash book ..	10 4 6	362 4 6
			77,129 15 5
14	Surplus during the year ..		44 14 0
	TOTAL .. Rs.		77,174 13 5

(SD.). M. D. CHATURVEDI, I.F.S.,
Chairman, Board of Management,
The Indian Forester.

(SD.). C. R. RANGANATHAN, I.F.S.,
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(SD.). V. S. KRISHNASWAMY, I.F.S.,
Honorary Editor,
The Indian Forester.

RECEIPTS AND EXPENDITURE OF THE *INDIAN FORESTER* FOR 1951

Item No.	Receipts	Amount	Item No.	Expenditure	Amount
	Rs. A. P.	Rs. A. P.		Rs. A. P.	Rs. A. P.
1	To subscription received for 1951 ..	13,414 9 0	1	By establishment charges ..	2,245 4 6
2	To sale proceeds of stray issues ..	409 3 6	2	By fees and allowances	35 0 0
3	To Advertisements	2,843 14 0	3	By printing charges for 1951 issues ..	11,918 1 10
4	To sale of reprints	187 5 0	4	By cost of paper : Printing .. .. 1,101 0 6 Illustrations .. 2,170 10 3	3,271 10 9
5	To interest on loans, etc. ..	996 12 0	5	By cost of half-tones and line blocks ..	1,368 7 3
6	To receipts from miscellaneous sources : Cost of share of blocks 436 13 0 Miscellaneous .. 59 14 0	496 11 0	6	By stationery and printing (approx.)	350 0 0
	Rs.	18,348 6 6	7	By postage and telegrams (approx.)	875 0 0
7	To loss during the year	2,614 0 1	8	By bank charges	220 6 6
			9	By income-tax and surcharge on loans, etc.	232 5 0
			10	By refunds of subscription ..	100 13 0
			11	By cost of stores, their maintenance and repairs, etc.	2 0 0
			12	By miscellaneous charges : Packing charges .. 163 5 9 Other charges (approx.) 180 0 0	343 5 9
	TOTAL .. Rs.	20,962 6 7		TOTAL .. Rs.	20,962 6 7

Outstanding Bills as on 31-12-1951

1. National Printing Works, Delhi, for printing of 1949 issues ..	Rs. 4,682 1 6
2. National Publications, Bombay, for printing of 1948 issues ..	Rs. 1,076 7 0
	5,758 8 6
Less subscription and advertisement charges recoverable (approx.) —	2,000 0 0
	3,758 8 6
Plus loss for 1951 as above	2,614 0 1
TOTAL LIABILITY ..	Rs. 6,372 8 7

(SD.). M. D. CHATURVEDI, I.F.S.,
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MANAGEMENT AND IMPROVEMENT OF FOREST GRAZING IN THE MADHYA PRADESH*

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Chief Conservator of Forests, Madhya Pradesh.

The State of Madhya Pradesh has a total land area of 1,31,686 sq. miles. Like the rest of India it is a predominantly agricultural State. An area of 53,373 sq. miles (40·5% of the land area) is devoted to cultivation and 61,824 sq. miles (47% of the land area) are classed as forest. Of the latter, an area of 37,336 sq. miles (60·4% of the forest area), the bulk of which is constituted as reserved forest is under the management of the Forest Department. The bulk of the remaining area under forest (excluding the rayatwari forest) which until recently was privately owned has vested in the Government in 1951 with the promulgation of the Abolition of Proprietory Rights Act. In this area most of the larger forests have just been handed over to the Forest Department for management, thus bringing the area under the control of the Forest Department to 44,562 sq. miles. It is very likely that before long the total area under the Forest Department may go up to about 50,000 sq. miles.

The total cattle population of the State is 19,529,400 which includes 360,225 sheep and 2,083,622 goats according to the 1951 census. In the year 1949–50, 50,92,464 cattle (26%) grazed in the 36,400 sq. miles of Government forests. Agriculture is carried out with the help of cattle which are also utilized as draught animals and provide milk and farm-yard manure. Cultivation of crops exclusively for obtaining fodder is negligible and, except in Berar, stall feeding is not practised to any appreciable extent due to its high cost. The general practice is to send cattle for grazing in the forests and waste lands and in the fields after the crops are harvested. The cattle are, therefore, inefficient and loss in efficiency is attempted to be made up by increase in numbers resulting in heavier incidence of grazing. There are large numbers of useless animals which reduce the available fodder supply.

Except in the plains of Chhattisgarh and Berar, which have little forests, the wide distribution of forests helps to supply the grazing requirements over a large area of the State. In the Government forests the pressure of grazing is the heaviest along the fringes of the larger blocks and in all the isolated blocks which are surrounded by villages. The animals required fo· day-to-day agricultural works can only be sent for grazing in the nearby areas. Many of the forest blocks are scattered amidst cultivation. Such blocks are subjected to intensive local demands for timber and firewood as well as grazing. The number of cattle seeking admission in the reserved forests has been steadily increasing on account of various causes.

The need for the supply of small timber and firewood from the forests is as great as the necessity for the provision of grazing. Although ideally provision of grazing in the

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* This paper was originally presented at the Eighth Silvicultural Conference, 1951.

reserved forests cannot be regarded as an absolute necessity, it is an indespensable and legitimate necessity in the Madhya Pradesh, with its large area under forests and their wide distribution. In fact the supply of local requirements of small timber and firewood and grazing for cattle are so important that they receive the highest priority in the policy of administration and management of forests. To ensure that this policy is effectively implemented, it is laid down by Government that a Revenue Officer should be associated with the preparation or revision of each working plan. When a Working Plan is ready, the Revenue Officer carries out a village to village enquiry to find out if it has made proper provision for the supply of the needs of the local population and provides for the grazing of maximum number of cattle without prejudice to the silvicultural requirements of the forests. Under the grazing settlement the entire forest area of a division is sub-divided into a large number of grazing units ; their extent being generally inversely proportional to the grazing demand in a locality. All units where the demand is excessive have villages with fixed numbers of cattle allowed to graze, listed to them. The total number of cattle is also fixed for the entire unit. The large grazing units with little demand are open to all comers. The grazing settlement and the Revenue Officers' Enquiry are special features of all forest Working Plans of this State. Among the first grazing settlements of this kind introduced in the State were those of Nagpur-Wardha (1912), Nimar (1913) and Yeotmal (1914).

The following extracts from the memorandum No. 5079; dated 28-9-1946 addressed by the Chief Conservator of Forests to the Government of Madhya Pradesh give an idea of the importance of the grazing problem and attempts made in the past to control grazing.

"6. Various measures have been adopted since the reservation of the State forests with the object of preserving and improving the forests and pastures. The first step was the exclusion of goats and sheep from the bulk of the reserved forests. This was followed by the closure of certain valuable forests to cattle grazing also. The extension of cultivation gradually increased the grazing pressure on the more accessible areas and complete closure applied in certain areas resulted in rank growth of grass which was unfavourable to the production of the tree species. The practice of periodic grazing was introduced later to remedy these defects. The forests were closed for varying periods after felling with the object of protecting the reproduction of tree species until a stage was reached when cattle could do no serious harm. Thereafter the closed areas were thrown open to grazing. While tree growth benefitted from such closures, continuous grazing for a long period soon neutralized the improvement done by periodic closures to the pastures subjected to intensive grazing.

"7. The demand for grazing increased gradually to a considerable extent in certain areas and it appeared that in such areas the provision of grazing and grass should be recognized as the main object of management. About the year 1915 it was decided that forests should be differentiated into two categories, namely, tree forests and grazing grounds. In the former the limiting incidence aimed at was three acres and closures were provided for protecting reproduction after fellings and again at intervals of ten years to permit the recovery of pasture. In the grazing grounds, the demand for grazing being acute, the limiting incidence aimed at was 1·5 acres but periodic closures could not be prescribed. The above figures appear to have been arrived at arbitrarily from general observations.

"8. To provide grazing concessions to cattle considered as essential for agricultural needs and to facilitate the exclusion of surplus stock where necessary, three classes of cattle were distinguished, namely, privileged, ordinary and commercial. Different grazing rates were fixed for each class.

"9. The grazing rules and the instructions at present in force were first drafted on the above principles over 30 years ago. Although no major modifications have been made

in the rules, the classification of the forests has been materially altered subsequently to provide for the grazing of more cattle in the reserved forests.

"10. The increasing tendency to rely for grazing in the reserved forests brought about by various external causes, e.g., increase in the cattle population, deterioration or decrease in private grazing grounds, disparity in the rates charged and general ignorance of and apathy towards the problem of live stock, culminated in widespread agitation and by 1930 mass agitation had started in certain districts. The Forest Department most regretfully observed that popular clamour for larger areas and cheaper grazing rates was allowed to override considerations of the preservation and improvement of the grazing grounds, the future welfare of live stock and agriculture and in fact the whole principle of the greatest ultimate good of the greatest number. A policy of appeasement appears to have guided the administration at this critical time.

"11. In response to a resolution moved in the Legislative Council in the year 1927, the Government appointed a Forest Committee in the year 1929 which included a majority of non-official members of the council to examine and report on various questions connected with the administration of the Forest Department. The report which was published in 1931, although not authoritative, because the Legislative Council was dissolved in 1930 before the Committee completed its work, contains useful recommendations on the question of grazing which are quoted below :—

"(1) Grazing should be in rotation and periods of closure be provided to permit of seeding and re-establishment of the roots of the grasses. Experiments should be at once started to see whether a shorter closure can be adopted with safety.

"(2) Where the grazing area is sufficiently large, we suggest that the area open should be divided into larger section open from the beginning of the rains and smaller one open after the middle of August, so that the grass has a chance to seed. This will be by way of experiment and if found difficult to work, need not become a permanent feature.

"(3) That the number of cattle be restricted to not less than $2\frac{1}{2}$ acres per head in forests intended mainly for the growth of trees, and to 1 to $1\frac{1}{2}$ acres in lands mainly intended for pasture. Here again research and experiment are necessary.

"(4) That cattle should not have to go more than five miles from their cattle sheds to the extreme end of their pasture ground so as to prevent the deterioration of pasture through excessive grazing by the concentration of the cattle near the village.

"(5) That cattle excluded from daily grazing by (4) above be provided for in cattle camps in the interior of the forests.

"The above recommendations clearly indicate that the necessity for restricting the incidence and for periodic closure to enable seeding and re-establishment of grasses was recognized as being essential although experimental data regarding incidences and closures were lacking".

In the year 1931 the Forest Department was asked by the Government to report on the existing policy and propose modifications with a view to abolish grazing restrictions in certain forests.

The Forest Department was alive to the necessity of relieving the so called distress by re-classification of forests based generally on the needs of the people, but it was not in favour of relaxing grazing restrictions to the extent of abolishing them altogether where the demand

for grazing was acute. Stress was rightly laid on the fact that the remedy was not unrestricted admission of cattle to grazing grounds but increase in the productivity of pastures. Although adequate experimental data were not available, the limit of stocking up to 2 acres per cow with periodic closures at intervals and the application of different rates to exclude excess cattle from heavily grazed areas were suggested.

In the year 1933, Government finally ordered *ab-initio* re-classification of the forests for the purpose of grazing control. The principle of gradual imposition of restriction was laid down and they were to vary according to the types of forests and their relative importance for timber and fuel production on the one hand and satisfaction of demands of grazing on the other. The classification ordered and the grazing restrictions to be aimed at were laid down as follows :—

A. Tree Forests :—

- (i) Moist type .. The limiting incidence was fixed at 4 acres per head of cattle.
- (ii) Dry type .. The limiting incidence was fixed at 2 acres per head of cattle for teak forests and 3 acres for mixed forests. Where grazing pressure was heavy, rotational closure of 3 to 5 years provided for in addition to the usual closure after the felling of tree crop.

B. Scrub Forests :—

- (i) Pasture forests .. The limiting incidence was fixed at 1 acre per head of cattle. In addition to closure after fellings repeated rotational closures were prescribed in the interest of pasture.
- (ii) Open pasture .. No restriction on number of cattle was prescribed but to improve pasture rotational closures were allowed.

C. Grass reserves.

D. Miscellaneous :—

In order to give effect to the above orders the reserved forests were rapidly re-classified and the grazing settlements of all Forest Divisions were overhauled. This resulted in relaxation of grazing restrictions in many areas. Under the revised classification allocation of areas to different classes was as follows :—

Classes of forests	Area in sq. miles	Percentage of total area
A. Tree Forests :—		
(i) Moist type ..	2,325	11·9
(ii) Dry type ..	8,622	44·0
B. Scrub Forests :—		
(i) Pasture forests ..	4,914	25·1
(ii) Open pasture ..	1,422	7·3
Total ..	17,283	88·3
C. Grass birs *D. Miscellaneous*	2,285	11·7
	19,568	100·0

The working of the above arrangement was critically examined by the Forest Department in 1946. As a result of the experience gained the following inherent defects were noticed :—

(i) the need for a separate class for areas requiring soil conservation measures was not recognized. Separation of steep slopes and badly eroded areas from the remainder and preservation of the physical features is of paramount importance in the hilly areas of Madhya Pradesh where the sources of several great river systems of India lie ;

(ii) the demand for grazing was laid down as the criterion for classifying forests as Scrub Forests. The grazing restrictions prescribed arbitrarily were inadequate even for the maintenance of pastures in stable condition ;

(iii) the rotational closures were applied in few units according to the instructions of the Government, the object of restricted application being to provide the maximum grazing facilities ;

(iv) the incidences and rotational closures were fixed arbitrarily and were not based on experimental data ;

(v) many areas which should have been classed as "Tree Forests" were allocated as "Scrub Forests" and heavy grazing was omitted to the detriment of the tree growth ; and

(vi) heavier grazing was permitted in many areas by the Revenue Officers than the prescribed incidences contemplated.

The available results of experiments carried out on the subject of grazing and pasture improvement in this state as well as in other States were also examined with a view to obtain reliable conclusions for practical application in the management of forest grazing and pastures.

As regards the experimental work done by the Forest Department in this State those carried out between the years 1931, and 1940 are worth mentioning. The work done in 1931–33 attempted to determine the yield of grass if hand-mown at intervals as against one cutting at the end of the growing season. Although fresh plots were laid out in 1932 and 1933 as a result of the experience gained in 1931, no reliable results were obtained. It was, however, realized that the effect of continuous grazing for various periods under different intensities and periods of subsequent closures must be determined for application in actual practice. A comprehensive investigation was commenced in 1934 in consultation with the Forest Research Institute, Dehra Dun, in Yeotmal and Sagar Forest Divisions. Nearly 150, 1/10 acre plots were laid out. The various treatment prescribed were 3 intensities of grazing and grazing closure cycles covering grazing from 1 to 10 years followed by closures for similar periods. These were repeated on 3 site qualities. Attempt was made to ensure initial comparability and to eliminate seasonal variations as far as possible. The plots were assessed up to 1937 and on analysis of the data the experiment was closed in 1938 as inconclusive when it was found that the effect of uncontrolled variables had completely swamped the variations due to treatments. It become obvious that such investigations are of a very complicated nature and the determination of proper technique is the first essential. Further work from 1938 to 1940 was, therefore, done with the objects of determining the best size of ultimate sampling unit, the number of sampling units necessary to represent the growth in each plot and the number of replications required per treatment to determine a valid estimate of experimental error. A paper on this work was published in the *Indian Forester* (January, 1946) by the Central Silviculturist. The conclusions are (i) with a standard error of 15%, ·001 acre is the most efficient size of sampling unit, (ii) the safe minimum

number of sampling units for the best size (·001 acre) of unit is 20, and (iii) the number of replications should be 30 for a significant difference of the order of 10% between treatment means. This work was of a pioneer nature in India for this intricate problem.

The main problem of finding experimental data for practical application remained unsolved. The results of some experiments carried out in Bombay and Uttar Pradesh were found to provide some useful indications, however. The work done at Bamburda (near Poona) in an area which was open to unlimited grazing prior to the experiment indicated that one animal for 2 acres is about the right limiting incidence, under the treatments given striking improvement took place in the yield as well as quality of grass from year to year and that the area could carry increasing number of cattle. The Uttar Pradesh experiment indicated that with grazing closure during the monsoon the production of grass is unaffected by the incidence of grazing during the rest of the year and rotational grazing during a year with an average incidence of one animal per acre leads to a definite deterioration in grass production. These indications point towards the conclusion that grazing for eight months with closure during the monsoon is to be preferred. The results of the revised investigation commenced in the Uttar Pradesh are not yet known.

Some contribution to our knowledge has also been made by the Agricultural Department of the State. From the forestry point of view, these consist of some earlier surveys of grasses, testing the fodder value of local grasses and other fodders, improving the quality of herbage on grazing lands, determination of the yield by artificial cultivation and evolution of a suitable mixture of the local fodder grasses. The following species were found to be of value :—

Local Name	Botanical Name
Sheda ..	.. *Schima nervosum.*
Paonia ..	.. „ *sulcatum.*
Saniba-bajra ..	.. *Andropogon purpuro-sericius.*
Mushan ..	.. *Iseilema laxum.*
Mothi-marvel ..	.. *Dicanthium caricosum.*
Lahan-marvel ..	.. „ *annulatum.*
Malhar ..	.. *Bothriocloa pertusa.*
Kadmor or Phuler	.. *Apluda aristata.*
Gadha sheda ..	.. *Chrysopogon montanus.*
Diwaratan ..	.. *Andropogon pumilus.*

Kusal grass (*Hetropogon contortus*) is very widely distributed in the forests but it is useful as fodder only when young.

A mixture of the above named 10 species is recommended for artificial cultivation by the Agricultural Department. The mixture gives the highest yield as compared to the yield of individual species. The yield of the mixture is 7,886 lbs. (green) and 3,533 lbs. (dry) per acre. The inclusion of legumes (*Alysicarpus rugosus* and *Indigofera linifolia*) is also recommended.

In view of the drawbacks of 1933 policy of re-classification and grazing control, by 1946 it was strongly felt by the Forest Department that its revision was most essential. Based

on the experience gained and the results of the investigations narrated briefly above the Forest Department formulated specific proposals with regard to the future policy of grazing control in the reserved forests and submitted the same for orders of the Government in 1946. No orders were passed by the then Government. Soon after a new Government assumed power and appointed a Forest Policy Committee, among the terms of reference of which were the recommendations of the Forest Department regarding re-classification of the reserved forests on the basis of functions, statement of grazing policy and the revision of the grazing rules. The Committee have submitted their recommendations which are under the consideration of the Government.

The main recommendation of the Forest Department is re-classification of the reserved forests on the basis of functions and control of grazing on the basis of such experimental results as are available so that the object of management of each class of forest may be achieved without detriment to its capacity of sustained yield. The classes proposed and grazing restrictions recommended are as under :—

I. Protection Forest—To include areas having steep and precipitous slopes (25° and over) ; the object of management being to preserve the physical conditions. The forests may be worked only under a system of scattered fellings and no grazing may ordinarily be allowed.

II. Tree Forest—To include areas where production of trees is the chief object of management. Grazing restrictions to be applied solely according to Silvicultural requirements. The limiting incidence recommended is 3 acres per cattle unit on the average area open to grazing. Where grazing pressure is heavy, in addition to the usual closures after felling, additional closures of 3 years at suitable intervals are recommended.

III. Minor Forest—To include areas in which the primary object of management is to provide grazing and fodder to the maximum extent possible consistent with their management on the principle of sustained yield of small timber, firewood and fodder. The limiting incidence is 2 acres per cattle unit. In addition to closure after felling of the tree crop, in the interest of preservation and improvement of pastures monsoon closures are also recommended.

IV. Pasture Forest—To include areas having little or no tree growth in respect of which the chief object of management is to provide fodder and grazing to the maximum extent possible, consistent with the preservation and improvement of pasture. The limiting incidence is one acre per cattle unit. Monsoon closures are also recommended. Trees providing shade and leaf fodder are to be protected and planted if necessary. Other tree species may be sacrificed in the interest of the growth of grass.

V. Miscellaneous—To include grass reserves and forest village areas, etc. The object of management of grass reserves is to provide cut fodder to the maximum extent possible.

The urgent necessity for the revision of the working plans and grazing settlements after the last war led to the constitution of a Working Plan Circle (since abolished as a measure of economy inspite of the strong protest of the Forest Department) in the State. The need for a revised grazing policy was keenly felt at this stage. But as stated above, the recommendations made by the Forest Department in this respect in 1946 have not yet received the final consideration of the Government. In the absence of orders on them, an attempt has been made to introduce all the desirable features of the recommendations in the post-war revisions of working plans and grazing settlements so far undertaken. Each Working Plan and grazing settlement is examined by a Revenue Officer and orders are passed by Government on each individually.

Out of the 28 working plans, the revision of nine plans and grazing settlements has been completed or is nearing completion and four more are under revision. Some idea of the progress made so far will be obtained from the following information given from some of the completed working plans and grazing settlements.

	Re-classification of forests						Total average area available for grazing every year	Total No. of grazing units	No. of cattle units provided for	Remarks
Name of revised W.P. and Grazing settlement	Protection forest	Tree forest	Minor forest	Pasture forest	Miscellaneous	Total area				
1	2	3	4	5	6	7	8	9	10	11
	sq. miles	sq. miles	sq. miles	sq. miles	sq. miles	sq. miles	sq. miles			
Allapalli and Pedigundam Ranges	..	191	..	32	..	223	32	..	No limit fixed	191 sq. miles of A class reserves entirely closed to grazing. Demand on 32 sq. miles of B class forests is light hence no limit.
Nagpur-Wardha	36	166	394	77	40	713	504	104	1,36,629	
North Chanda	..	438	694	37	12	1,181	974	55	2,84,645	
Balaghat ..	79	444	329	..	69	921	755	49	1,22,862	
Mandla ..	44	862	317	45	160	1,428	1,082	120	2,73,286	
Hoshangabad ..	74	826	5	..	119	1,024	704	33	1,45,295	
Nimar ..	..	1,267	250	12	152	1,681	1,319	68	3,16,063	

The special features of the plans and the grazing settlements which have already been revised, are revised classification of the forests according to functions, attempt to reduce grazing pressure and to limit the grazing incidences to the figures recommended in 1946, introduction of periodic closures and monsoon closures wherever possible without causing hardship to the people and with their consent and finally, constitution of Pasture Working Circle where feasible. In general, these measures have the effect of reducing grazing pressure where it is heavy and diverting some cattle to areas where accommodation is available maintaining productivity of the grazing grounds under heavy pressure of grazing and greater attention being paid to the forests included in the Pasture Working Circles in the interest of preservation and improvement of pasture.

It must be stated, however, that in many cases the limiting incidences are not attained as, to do so, considerable numbers of cattle would have to be excluded. The process has to be gradual and patient propaganda in the country-side is needed. The most convenient form of monsoon closure for practical application has been found to be triennial closure. The prescriptions of Pasture Working Circles include, among others, a limiting incidence of one acre per cattle unit, monsoon closures, prohibition of grass cutting in the closed area during the monsoon, preservation of shade giving and leaf fodder species felling of trees only

in the interest of pasture improvement and artificial restocking of pastures by superior grasses, planting of fodder yielding tree species and eradication of weeds.

The application of these measures is intended to be continued by a gradual process in all the working plans and grazing settlements of the 19,400 sq. miles of pre-1948 reserved forests. Their application to the large areas of forests of the States which merged in 1948 and the private forests which have already been handed over to the Forest Department in 1951 and those that are shortly to be handed over, is an objective of the Forest Department which must await fulfilment in future when working plans and grazing settlements are made for those areas.

Meanwhile, the continuation of research on this subject from the point at which it was left off on account of the last world war is, it is felt, a matter of urgent necessity. A scheme for the reorganization of the Silvicultural Research branch including an Agrostological section is pending with the Government.

In conclusion I have to express my thanks to Shri R. N. Datta, I.F.S., Conservator of Forests, Central Circle, and Shri R. B. Mujumdar, Silviculturist, Madhya Pradesh, for their assistance in collecting the information for this paper.

TULASI: THE SACRED PLANT OF INDIA

Is it Foreign to the people of this country ?

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Place of Origin—Holy Basil (Indian name *tulasi*, scientific name *Ocimum sanctum* Linn.) is available in all parts of India, Burma and Ceylon. In India, it is found on the Himalayas up to a height of 8,000 feet. Hindoos very often plant it in their houses for use in religious ceremonies. Mr. Parker never found it growing spontaneously in the jungles of the Punjab. Here it is always found cultivated in the houses and gardens. It is, therefore, possible to presume that it does not grow by itself in this province. (Parker ; A Forest Flora for the Punjab).

As the plant has not travelled for away from the human influence, Sir George Watt has expressed the opinion that the plant is doubtfully indigenous (Watt ; A Dictionary of the Economic Products of India).

Its habitat extends from western Asia and Arabia to Malaya, Australia and Pacific islands.

Held Sacred in Greece—Basil is considered sacred by the churches of Greece. It is commonly regarded as the health bestowing plant by the people of the mediterranean coasts. Hobson Jobson (London 1903, page 931), embodied an article on Holy Basil by Yule and Burnell. The quotation from G. T. Bent's book "The Cyclades" (1885, page 328) contained in this article reveals that basil is praised in Greece for its mystic properties. It is said that it grew on the grave of Christ and this is why it is adored by the Eastern Church. On St. Basil's day women take sprigs of this plant to be blessed in church. On returning home they place some sprigs on the floor of the house to secure luck for the ensuing year. Every member of the family tastes a bit of the basil and the rest is kept in almirahs with the belief that it preserves the clothes from rats, mice, cockroaches and other insects, for nearly a year.

Sacred in Europe too—It can be gathered from this description that the *tulasi* plant has been considered sacred by the people outside India for at least two thousand years. Ancient as well as modern French and Greek languages have named Basil as 'Royal' or 'King-like'. Literally translated, therefore, the English and the French names of Basil mean 'Holy Basil', or 'Monk's Royal Basil' or 'Saint's Royal Basil'. The latin name – *Ocimum sanctum* – is also indicative of its sacredness. As it evident from these names the *tulasi* plant is honoured and adored in Europe in the same way as it began to be worshiped in India in the middle ages.

Not mentioned in Vedic Literature—We do not find its adoration in India as old as in Europe. It has been in use in India for medicinal purposes from a period prior to 300 B.C., but we cannot trace its worship before the middle ages. At the same time it is difficult to say whether the people of this country were aquainted with the *tulasi* plant prior to 300 B.C., or not ? No mention of the Holy Basil has been made in the Vedās, Āranyakās, Brāhmanās, or even in the universally accepted twelve ancient Upanishads.

Tulasi – not an Ancient Name—The most prevalent name for this plant in India is *tulasi*. This is not a very old name. We do not find this name in *Charaka*, *Sushruta* and other ancient Ayurvedic compilations. At that time (approximately before second century

B.C.) it was called *Surasa* (with abundant juice or scented juice or having property of producing salivation) and *Apetarākshasi* (possessing property of destroying demonic diseases – gorms). *Charaka* gives it the masculine name *Suras*, whilst (*Sushruta* describes it by a feminine name, viz., *Surasā* (the long suffix rendering it feminine). Dallan the commentator of *Sushruta Samhita* states that *Surasa* is the same as the commonly known *tulasi*. This indicates that by the time of Dallan (1060–1260 A.D.) the plant had become popular by the name of *tulasi*. Amongst the Sanskrit works we find this name at first in some of the *Purānās* (books of Indian mythology), i.e., works of the middle ages. These were composed during the seventh or eighth century A.D. The name *tulasi* was incorporated in the text-books of Ayurvedic *Materia Medica* written after this period. In the Puranic literature it has been described as *Vrinda* (with flowers in whorls ; or according to Indian mythology a devoted self-extinguished-Sati-lady named *Vrinda* incurred the wrath of God Vishnu and was doomed to be born as *tulasi* plant on this earth as an offering for the appeasement of Vishnu's wrath). We do not find this name in the text-books of Ayurvedic treatment and *Materia Medica* ; whilst the names *Surasa* and *Apetarākshasi* of *Charaka* and *Sushruta* respectively, are not met with in the *Purānās*.

In Religious Scriptures—It is only in one place in the religious scripture of *Shankha* and *Likhita* that we find a description of the internal use of Basil leaves. The original of this scripture has not been found in its entirety up till now. Scattered pieces have been collected and published by the Bhandarkar Oriental Research Institute, Poona. If we accept the antiquity of this scripture we shall have to admit that *tulasi* has been in use since very old times.

Shankha and *Likhita* have advocated that the signs of *Chakra* (Circle), etc., should also be borne on the body along with the internal use of basil. All this pertains to the Vaishnava sect whose origin cannot be traced back to very remote times. Though the period of this scripture is an ancient one, the fact is rendered dubious on account of the compilation and publication of scattered pieces and the non-availability of the whole original scripture in a collective state.

The word *Tulasi-Bhoo* appears at one place in the *Atharva Ved* supplement in connection with the description of black mustard. No Sanskrit word for basil is found in the *Sutras* of Pānini. Even in the Chapter on 'verbal conjugations' the word *Surasa* and not *tulasi* appears. And if this be taken as a synonym for *tulasi* is would mean that the plant must have been in use at this time.

In Upanishads—Thus we see that the whole of the Vedic literature is silent about *tulasi*. It has been mentioned by names other than *tulasi* in the earliest treatises on medicine. It has been applauded by the name of *tulasi* in the Purānas and the Vaishnava Upanishadās like Tripād Vibhuti Mahānārāyanopanishad, Sām Rahasyaopanishad, Rām Rahasyopanishad, Vāsudevopanishad, etc. A separate small scripture known as *tulasi* Upanishad is also available. It gives a description of its properties, methods of plucking and watering it and instructions regarding its usages in ritual worship. *Tulasi* Upanishad also gives hints on the methods of its use for curing diseases and keeping the body healthy.

TESTING OF WOOD PRESERVATIVES

PART I

Copper-chrome-boric composition

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SUMMARY

The wood preservative copper-chrome-boric acid composition which is a modification of the copper-chrome-arsenic composition (ASCU) replacing arsenic pentoxide by boric acid, was tested in the laboratory and in the field. These tests indicated that :—(1) thin veneer specimens treated with this preservative were all sound in the test yard after about 2 years, while the untreated ones were all destroyed within 5–10 months ; (2) the preservative gets satisfactorily fixed in wood. The following conclusions were, therefore, arrived at :—(1) this preservative cannot be considered as a substitute for ASCU, but can be used in place of Celcure ; (2) for treatment of timber for use in dwelling houses and packing cases, it may be preferred to ASCU which is likely to give poisonous arsenic fumes under a fire accident ; (3) an absorption of 0·75 to 1·0 lb. per cubic foot for house-building timbers, and 0·5 lb. per cubic foot for packing case timbers, can be expected to give satisfactory protection against attack by fungi and insects including termites and (4) for treatment of poles, piles, etc., it is best to wait till sufficient service data are obtained.

INTRODUCTION

The chief characteristics of any good wood preservative are (1) toxicity and (2) permanence, i.e., resistance to fungi and insects, and to evaporation and leaching. The copper-chrome-boric composition[1] is a modification of the well known copper-chrome-arsenic[2] composition (Ascu) replacing arsenic pentoxide by boric acid. While this modification is advantageous from the point of view of utilizing the indigenous boric acid in place of the imported arsenic pentoxide, it requires to be ensured that the two principal characteristics of a good wood preservative, namely toxicity and permanence have been retained. Experiments were, therefore, conducted to test these properties.

EXPERIMENTAL

In order to find out the resistance of the preservative to fungi and insects, accelerated 'thin-strip' tests were undertaken. *Semul* veneers 6 inches long, 2 inches wide, and 1/8 inch thick were treated with 10, 8, and 6 per cent solutions of the preservative under 50 lbs./sq. in. pressure for 30 minutes. Six specimens treated with each concentration of the preservative were oven-dried and another six were air dried. For purposes of comparison a duplicate set of specimens was treated with original copper-chrome-arsenic composition. All these specimens along with untreated specimens were then laid in the 'test-yard' in the open, on 13th November, 1950. The condition of these specimens after nearly two years is given in Table No. 1.

Laboratory toxicity tests on this preservative have also been undertaken recently. The results will be reported as soon as the experiments are completed.

Since the preservative consists of copper sulphate, boric acid and sodium dichromate the question of any depletion of the preservative due to evaporation does not arise. Therefore only leaching tests have been carried out. For this purpose, specimens from *chir* and *sal* sapwood 5·1 × 2·6 × 1·6 c.m. were treated under vacuum, 24 inches Hg, for 30 minutes followed by 50 lbs./sq. in. pressure with the preservative in 8, 6 and 4 per cent concentrations. Eight specimens treated with each of the three concentrations were then air-dried for one week, and a similar number for three weeks. At the end of these periods they were oven-dried for 48 hours and subjected to leaching. The method adopted for leaching was substantially that described earlier[3]. Four blocks at a time from each of the above mentioned treatments were placed in a wide mouth ground-in-stopper glass bottle along with 200 c.c. of distilled water, and subjected to shaking in a specially built machine, at room temperature. The shaking was continued for 6 hours; during this period the bottle was shaken about twenty thousand times. At the end of this period the solution in the bottle was filtered with repeated washing of the blocks, and made up to 250 c.c. in a standard flask. The contents were then analysed for chromium, copper and boric acid. The remaining four blocks were heated for 6 hours along with 200 c.c. of distilled water at 40°C. and immediately subjected to shaking. The results of analysis are given in Table No. 2.

In order to find out the best ratio of boric acid to sodium dichromate for obtaining satisfactory fixation of boric acid, sixteen blocks of each of *chir* and *sal* were treated, as described earlier, with various concentrations of solutions, each containing one per cent of boric acid; the dichromate varyed from 0·2 to 1·5 per cent. They were then subjected to leaching as described above. The results are given in Table No. 3.

For purposes of comparison, sixteen blocks of each of *chir* and *sal* were treated with 1 per cent boric acid alone and subjected to leaching. These results are given in Table No. 4.

DISCUSSION

It will be seen from the results on the leaching tests vide, Table No. 4, that only 35 and 38 per cent of boric acid get fixed in *chir* and *sal* respectively under favourable conditions, i.e., leaching after 3 weeks at 30°C. When leaching was done after one week and at 40°C. nearly 70 per cent of the chemical was lost both in *chir* and *sal*. These results are in conformity with earlier results on leaching obtained by K. M. Harrow[4] in New Zealand. He found that treated specimens when exposed to the weather for six months lost 30 to 60 per cent of boric acid.

Addition of 1·5 times of Sodium dichromate to boric acid results in a fixation of nearly 80 per cent of boric acid in *chir* when leaching was done at 28°C. after three weeks vide, Table No. 3. Even at 40°C. the leaching in the above was only 28 per cent, i.e., a 72 per cent fixation was obtained. After one week 60 and 50 per cent of boric acid were fixed at 28° and 40°C. respectively. In the case of *sal* best fixations were obtained when the ratio of boric acid to dichromate was 1 : 0·75. Under these conditions the fixations after 3 weeks were 68 per cent and 63 per cent when leaching was done at 28°C. and 40°C. respectively; 65 per cent and 60 per cent when leaching was done after one week and at 28° and 40°C. respectively. It is interesting to note that though the fixation of boric acid in *sal* is greater than in *chir*, the reverse is the case when a mixture of boric acid and dichromate is impregnated in the above species of timber vide, Table Nos. 4 and 3. An explanation is found in the fact that whereas considerable quantities of dichromate were leached out from the *chir* blocks when a mixture of boric acid with varying amounts of dichromate were impregnated, practically no dichromate was leached out from the *sal* blocks. This shows that there is a preferential fixation of chromium to boron in *sal*. That is further borne out by the fact that for fixation of boric acid when in admixture with sodium dichromate the optimum is reached when their ratio is 1 : 0·75; for any further increase in the dichromate content an adverse effect on boron fixation results.

From the results in Table No. 2 it is clear that with *chir*, even under unfavourable conditions, the percentage of the copper-chrome-boric preservative lost due to leaching after one week and at 40°C. is less than 2·5 per cent. Under favourable conditions, i.e., leaching after 3 weeks and at 25°C. the loss is less than 1 per cent. In the case of *sal* a maximum of 6·05 per cent of the preservative was leached out after one week and at 40°C. and a minimum of 0·95 per cent was leached out after three weeks and at 25°C. Compared to the loss of 3–4 per cent of the original copper-chrome-arsenic composition due to leaching reported[5] from this laboratory several years back, and 10·69 per cent after 11 days and 2·55 per cent after 24 weeks reported from the Bell Telephone Laboratory[6], the present figures for the copper-chrome-boric composition can be taken as favourable. The lower figures in this case may be attributable to the lower solubility in water of boric acid as compared to arsenic pentoxide (solubility of boric acid at 21°C. is 5 per cent; solubility of arsenic pentoxide is very high).

Now, if we look into the percentage of the individual components leached out under the above conditions, it is interesting to note that the chief toxic ion, copper, is almost entirely fixed both in *chir* and *sal* under all conditions of the experiments. As regards the percentage limits of the other two ions (boron and chromium) leached out, the figures are :—

Species	Boric acid	Sodium dichromate	Condition of leaching
Chir	11·50	0·66	1 week and at 40°C.
,,	4·11	Traces	3 weeks and at 25°C.
Sal	21·40	4·60	1 week and at 40°C.
,,	5·54	Traces	3 weeks and at 25°C.

In the leaching experiments conducted at the Bell Telephone Laboratory, the following results were obtained with the copper-chrome-arsenic composition :—

Potassium dichromate	Copper sulphate	Arsenic acid	Total salts	Time of leaching after treatment
17·52	3·02	0·27	10·69	11 days
2·19	3·77	0·45	2·55	24 weeks

The results on the leaching tests obtained by the inventor[2] of the copper-chrome-boric acid composition on *semul* specimens are given below :—

Serial number of experiment	Percentage concentration of chemical in treating solution			Percentage of chemical (estimated on the original quantity injected) leached out after 20,000 shakes in 100 c.c. of water	
	$CuSo_4\ 5H_2O$	$H_3B_2O_6$	$Na_2Cr_2O_7$	$CuSO_4$	$H_3B_2O_6$
1	1·0	1·0	0·5	9·3	18·1
2	1·0	1·0	1·0	6·2	12·3
3	1·0	1·0	1·5	1·0	5·5
4	1·0	1·0	2·0	Traces	4·4
5	1·0	1·0	2·5	Traces	2·3

Sodium or Potassium dichromate is used to fix toxic chemicals in wood. It will be seen in the data presented in the above table that proper fixation of copper sulphate and boric acid does not take place till 2·5 grams of sodium dichromate are used with one gram each of copper sulphate and boric acid in solution. When only 2 grams of sodium dichromate are used

while copper sulphate is alone fixed, boric acid is still leaching out to the extent of 4·4 per cent of the original. We may, therefore, conclude that while copper sulphate can be fixed in wood when dichromate is used in the ratio of 1 : 1, for fixation of boric acid the ratio must at least be 1 : 1·5. Similar results are now reported on *chir* specimens.

The fixation of inorganic ions in timber is a very complex phenomenon. It is considered that in the case of single ions either the more soluble ion with higher valency is reduced to a less soluble ion with a lower valency by interaction with reducing substances (both chemicals and enzymes) in timber as in the case of dichromate to trivalent chromium or during the course of exposure to the elements, water, light, air and heat, a less soluble basic salt is produced as in the case of zinc chloride to basic zinc-oxychloride or both the above phenomena take place as in the case of copper sulphate. It is said[11a] that cupric copper is, under certain conditions, reduced to cuprous copper, and also that in the presence of acetic acid a basic copper acetate is formed in timber. Fungi like *Polyporus*, *Coniophora* and *Merulius* are said to produce oxalic acid which reacts with copper sulphate in timber converting it into copper oxalate which is non-fungicidal. Certain fungi are also said to convert arsenic compounds to dimethyl arsine gas, thus depleting the arsenic content[11c] in treated timber. In general, "precipitation" is caused in timber by many different organic compounds which contain hydroxyl and aldehyde groups. A water extract of wood causes a precipitation like that induced by dextrose. It can also be shown that most of the chromium in treated wood is in the trivalent state. The rate of reaction is found to be dependent on temperature[6 and 7]". Further, apart from reduction reactions, other chemical reactions take place in timber amongst the chemicals introduced in timber during treatment and the chemicals already present in timber, resulting in formation of less soluble salts. For example, it was found in this laboratory that copper sulphate reacts with abietic acid in *chir* and forms the highly insoluble copper abietate. Again, when two or more ions are introduced in timber the above reactions become extremely complex due to perferential adsorption and affinity phenomena. The result is that copper gets fixed in preference to both arsenic and boron ; dichromate gets fixed better in *sal* than in *chir*. Such variations in results occur not only owing to variations in the chemical contents in different species of timber, but also owing to differences in the chemical contents of both the soil and the atmosphere where such treated timber is used. Detailed investigations on the mechanism of fixation of inorganic preservatives in timber, grasses and textiles are under way in this laboratory. Preliminary results indicate that the fixation is less in grasses and practically nil in pure cellulose, found in cotton fabrics, as compared to timbers.

Results on the condition of treated *semul* specimens vide, Table No. 1 show that after nearly two years of exposure in the yard all the treated specimens are sound. Some of the untreated specimens were destroyed within 5 to 10 months. Within 2 months after laying in the yard, the untreated specimens were slightly attacked by mould and were finally rejected due to both white ant and fungus attack. These thin specimens, it may be remarked expose a specific surface, i.e., surface per unit volume, nearly 8 times that of normal test specimens ($2' \times 2'' \times 2''$) ; therefore, they can be considered to deteriorate 8 times as fast as the bigger specimens. Experiments on the prophylactic treatment of *semul* logs and *chir* sleepers using this preservative have given satisfactory results. These will be reported in a further publication.

According to tests on fungus 'Madison No. 517' the killing concentration (of anhydrous compound – percentage by weight of culture medium) for borax is 0·13, boric acid 0·25, arsenic trioxide 0·025, copper sulphate 0·064, copper arsenate 0·04 to 0·05[8]. K. M. Harrow[9] has recently found that the toxic loading (killing concentration) of boric acid is between 0·5 and 0·9 per cent or an absorption of 0·12 to 0·23 lb. dry salt per cubic foot when the test fungi used were *Coniophera cerebella*, *Poria vaporaria* and *Lenzites trabea*. Harrow

also found that a minimum safe loading for building timber to preserve it against Anobium[9] attack with boric acid would be 0·4 per cent by weight on oven dry basis. Australian workers recommend treatment of timber with 1·25 per cent boric acid for protection against *Lyctus*. Recently a few experiments were started to test the efficacy of boric acid against termites in this laboratory. Treated specimens introduced in termite mounds show that below 0·3 lb. per cubic foot absorption, the specimens are attacked. The tests are continued. Madison reports a service life of 12 years against fungus and termites for boric acid-borax (50 : 50) treated specimens vide, Table No. 6.

Service results with Celcure are given in Table 5. These show satisfactory results after 21 years. The untreated specimens were all destroyed within one to two years. Similar results were obtained in other countries vide, Table No. 6. The preservative consists of copper sulphate, sodium or potassium dichromate, acetic acid and water in the proportion of 5·6 : 5·6 : 0·25 : 88·55 respectively. The role of acetic acid is to keep the chemicals in solution during the treatment process and then to evaporate off leaving an insoluble copper-chrome-salt. To hasten the process it is recommended to steam the treated timber[10]. If all the acetic acid is not removed there is a danger of leaching of the chemicals[7]. The use of boric acid in place of acetic acid has many advantages – corrosion of the apparatus is reduced, no steaming of the treated timbers is necessary, protection of timbers against borers is secured. Even considering that boric acid is not sufficiently toxic to fungi and termites, the same amount of copper that is necessary to protect wood against fungi and termites as is obtained by using Celcure, weight for weight, can be had in the copper-chrome-boric acid composition if the latter is impregnated in wood at a rate of 1·5 times that of the former. An absorption of about 1·2 lbs. dry salt per cubic foot for outside locations and 0·6 lb. for inside locations is considered necessary with Celcure for protection of timber against termites, borers and fungi.

It may, therefore, be concluded from the experiments so far carried out with copper-chrome-boric composition (1) that the copper-chrome-boric composition cannot be considered as a substitute for Ascu as the former contains boron which is 10 times less toxic than arsenic (2) that it is a good substitute for Celcure (3) that for treatment of timber for use in dwelling houses and packing cases it may be preferred to Ascu, as the former does not contain arsenic which gives off poisonous fumes when the treated timber is on fire and (4) that an absorption of 0·75 to 1·0 lb. per cubic foot should give satisfactory service for house building timbers and 0·5 lb. for packing case timbers. Whether this composition gives equally satisfactory service life as Celcure if it is impregnated at the rate of 1·5 times the scheduled absorptions for Celcure for poles, can only be satisfactorily settled by actual service tests. Theoretical considerations, however, indicate that it may prove satisfactory.

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TABLE 1

Durability tests with treated and untreated Semul veneer strips

Date of installation : 13-11-1950
Date of last inspection : 16-7-1952

Serial No.	Preservative used	Percentage concentration of the preservative employed in water solution	Absorption in lbs. dry salt per cu. ft.	Methods of drying the specimen before installation	Condition of specimen
1	2	3	4	5	6
1	Copper-chrome-boric composition	10	3·3	Air-dried	Sound
2	,,	,,	3·4	,,	,,
3	,,	,,	3·2	,,	,,
4	,,	,,	3·5	,,	,,
5	,,	,,	3·4	,,	,,
6	,,	,,	3·4	,,	,,
7	,,	,,	3·7	Oven-dried	,,
8	,,	,,	3·4	,,	,,
9	,,	,,	3·2	,,	,,
10	,,	,,	3·6	,,	,,
11	,,	,,	3·2	,,	,,
12	,,	,,	3·5	,,	,,
13	,,	8	1·6	Air-dried	,,
14	,,	,,	1·9	,,	,,
15	,,	,,	1·6	,,	,,
16	,,	,,	1·5	,,	,,
17	,,	,,	1·7	,,	,,
18	,,	,,	1·7	,,	,,
19	,,	,,	1·9	Oven-dried	,,
20	,,	,,	1·7	,,	,,
21	,,	,,	1·8	,,	,,
22	,,	,,	2·0	,,	,,
23	,,	,,	2·0	,,	,,
24	,,	,,	1·6	,,	,,
25	,,	6	1·6	Air-dried	,,
26	,,	,,	1·4	,,	,,

(*contd.*)

TABLE 1—(*contd.*)

Serial No.	Preservative used	Percentage concentration of the preservative employed in water solution	Absorption in lbs. dry salt per cu. ft.	Methods of drying the specimen before installation	Condition of specimen
1	2	3	4	5	6
27	Copper-chrome-boric composition	6	1·4	Air-dried	Sound
28	,,	,,	1·2	,,	,,
29	,,	,,	1·5	,,	,,
30	,,	6	1·5	,,	,,
31	,,	,,	1·6	Oven-dried	,,
32	,,	,,	1·4	,,	,,
33	,,	,,	1·4	,,	,,
34	,,	,,	1·5	,,	,,
35	,,	,,	1·5	,,	,,
36	,,	,,	1·6	,,	,,
37	Untreated	Control	..	Air-dried	Destroyed by termites by 25-4-1951
38	,,	,,	..	,,	,,
39	,,	,,	..	,,	,, by 29-9-51
40	,,	,,	..	,,	,,
41	,,	,,	..	,,	,,
42	,,	,,	..	,,	,,
43	,,	,,	..	Oven-dried	Destroyed by termites and fungus by 29-9-51
44	,,	,,	..	,,	,,
45	,,	,,	..	,,	,,
46	,,	,,	..	,,	,,
47	,,	,,	..	,,	,,
48	,,	,,	..	,,	,,
49	Copper-chrome-arsenic composition (ASCU)	10	3·2	Air-dried	Sound
50	,,	,,	2·9	,,	,,
51	,,	,,	3·6	,,	,,
52	,,	,,	2·8	,,	,,
53	,,	,,	2·6	,,	,,
54	,,	,,	2·8	,,	,,
55	,,	,,	2·7	Oven-dried	,,

(*contd.*)

TABLE 1—(*concld.*)

Serial No.	Preservative used	Percentage concentration of the preservative employed in water solution	Absorption in lbs. dry salt per cu. ft.	Methods of drying the specimen before installation	Condition of specimen
1	2	3	4	5	6
56	Copper-chrome-arsenic composition (ASCU)	10	3·1	Oven-dried	Sound
57	,,	,,	3·0	,,	,,
58	,,	,,	2·8	,,	,,
59	,,	,,	2·9	,,	,,
60	,,	,,	3·1	,,	,,
61	,,	8	2·0	Air-dried	,,
62	,,	,,	1·6	,,	,,
63	,,	,,	2·0	,,	,,
64	,,	,,	2·0	,,	,,
65	,,	,,	2·0	,,	,,
66	,,	,,	2·5	,,	,,
67	,,	,,	2·5	Oven-dried	,,
68	,,	,,	2·0	,,	,,
69	,,	,,	2·7	,,	,,
70	,,	,,	2·8	,,	,,
71	,,	,,	2·7	,,	,,
72	,,	,,	2·4	,,	,,
73	,,	6	1·8	Air-dried	,,
74	,,	,,	1·7	,,	,,
75	,,	,,	2·0	,,	,,
76	,,	,,	1·2	,,	,,
77	,,	,,	1·9	,,	,,
78	,,	,,	2·0	,,	,,
79	,,	,,	1·8	Oven-dried	,,
80	,,	,,	1·8	,,	,,
81	,,	,,	1·8	,,	,,
82	,,	,,	2·0	,,	,,
83	,,	,,	2·0	,,	,,
84	,,	,,	1·7	,,	,,

TABLE NO. 2

Results on leaching of chir and sal specimens treated with copper-chrome-boric composition

Leached after one week									Leached after three weeks								
Original percentage concentration of preservative	Percentage of original boric acid leached		Percentage of original copper sulphate leached		Percentage of original sodium dichromate leached		Total percentage of original preservative leached		Original percentage concentration of preservative	Percentage of original boric acid leached		Percentage of original copper sulphate leached		Percentage of original sodium dichromate leached		Total percentage of original preservative leached	
	at 25°C.	at 40°C.	at 25°C.	at 40°C.	at 25°C.	at 40°C.	at 25°C.	at 40°C.		at 25°C.	at 40°C.	at 25°C.	at 40°C.	at 25°C.	at 40°C.	at 25°C.	at 40°C.
Species : *Chir*																	
7·99	6·80	11·50	Traces	Traces	0·49	0·66	1·40	2·38	7·99	5·90	9·90	Traces	Traces	0·48	0·49	1·20	2·00
5·47	5·39	6·90	,,	,,	Traces	Traces	0·93	1·19	5·47	4·11	4·62	,,	,,	Traces	Traces	0·70	0·79
3·78	8·90	9·08	,,	,,	0·19	0·19	1·60	1·60	3·78	6·80	7·40	,,	,,	,,	,,	1·20	1·30
Species : *Sal*																	
7·72	13·05	14·80	Traces	Traces	1·00	1·60	2·70	3·40	7·72	5·54	8·20	Traces	Traces	Traces	0·80	0·95	1·80
5·71	15·20	15·30	,,	,,	3·44	4·13	4·20	4·60	5·71	13·20	13·50	,,	,,	2·33	2·35	3·30	3·40
3·78	20·30	21·40	,,	,,	3·12	4·60	5·10	6·05	3·78	13·00	18·60	,,	,,	1·56	1·70	3·04	4·20

TABLE NO. 3

Results on the leaching of boric acid and sodium dichromate in chir and sal specimens when treated with 1 per cent of boric acid and varying amounts of sodium dichromate

	Leached after 1 week						Leached after 3 weeks					
					Chir							
Percentage of sodium dichromate ..	1·5	1·25	1·0	0·75	0·5	0·2	1·5	1·25	1·0	0·75	0·5	0·2
Per cent boric acid leached at 28°C. ..	39·34	36·78	44·67	48·01	51·03	51·30	19·45	34·77	39·79	45·83	44·18	42·2
Per cent boric acid leached at 40°C. ..	49·46	44·15	55·74	53·01	53·22	56·30	28·17	42·42	51·00	51·24	51·20	52·20
					Sal							
Per cent boric acid leached at 28°C. ..	41·77	46·97	43·46	34·51	35·49	45·70	34·86	43·75	37·07	31·68	31·98	34·6
Per cent boric acid leached at 40°C. ..	43·19	58·44	52·17	40·14	52·38	55·20	42·62	53·52	45·94	36·96	44·02	44·09
					Chir							
Per cent sodium dichromate leached at 28°C.	26·15	15·36	6·38	1·60	Traces	Nil	7·29	3·31	2·36	Traces	Nil	Nil
Per cent sodium dichromate leached at 40°C.	32·29	18·69	19·16	5·23	0·78	Nil	11·38	4·12	3·21	Traces	Nil	Nil

In the case of sal only traces of sodium dichromate were leached out both at 28 and 40°C.

TABLE No. 4

Results on the leaching of boric acid in chir and sal specimens when treated with 0·97 per cent of boric acid

	Leached after 1 week		Leached after 3 weeks	
	Chir	Sal	Chir	Sal
Per cent boric acid leached at 30°C.	67·60	68·50	65·50	61·60
Per cent boric acid leached at 40°C.	69·40	68·60	66·60	66·60

TABLE No. 5

Durability of Treated Timbers

Antiseptic :—Celcure *Treatment Process* :—Pressure

Received from—Mr. William Sandison, 110, East Clyde Street, Hetersburg, Scotland, M/s. The Celcure and Chemical Co., Ltd., 41, Saw-Mill Road, Glasgow.

Date laid down 17-3-1931.

Date of Inspection 24-1-1952.

Serial No.	Species	Absorption lbs./cu. ft. (Dry salt)	Condition of test piece on date of inspection			
			Treated		Untreated	
			Period		Period	
			Years	Months	Years	Months
1	*Pinus longifolia*	1·32	N —	—	Dw 0	7
2	*Adina cordifolia*	1·12	Sw —	—	Dwf 0	7
3	*Picea morinda*	0·92	Bw —	—	Dw 1	7
4	*Abies pindrow*	1·75	Mw —	—	Dw 0	4
5	*Bombax malabaricum*	1·77	Sw -	—	Dw 0	7
6	*Schleichera trijuga*	2·16	Dwf 11	8	Dwf 2	8
7	*Terminalia tomentosa*	0·61	Dwf 5	10	Dw 2	8

Legend :—N — No attack ; Sw — Slight termite attack ; Mw — Moderate termite attack ; Bw — Bad termite attack ; Dw — Destroyed by termites ; Df — Destroyed by fungus ; Dwf — Destroyed by termites and fungus.

TABLE No. 6

*Condition of round southern yellow pine experimental fence posts on the Harrison Experimental Forest, Saucier, Miss. after about $8\frac{1}{2}$ to 23 years of service (Treated posts were installed late in 1936 and thereafter)**

Preservative	Post in test	Form of Preservative	Retention of Preservative: Minimum	Retention of Preservative: Maximum	Retention of Preservative: Average	Retention of Preservative: Standard deviation	Method of treatment	Condition of posts December '49: Serviceable		Removed on account of: Decay		Decay and termite attack		Termite attack		Total removed		Average life
	Number		lbs./cu. ft.	lbs./cu. ft.	lbs./cu. ft.	lbs./cu. ft.		Number	Per cent	Number	Per cent	Number	Per cent	Number	Per cent	Number	Per cent	Years
1. Borax-boric acid (50–50 mixture)	97	Salt	0·64	1·32	0·92	0·11	Pressure	22	22·7	10	10·3	32	33·0	33	34·0	75	77·3	12·0
2. Celcure (acid-cupric chromate)	96	..	0·75	1·05	0·92	0·08	..	89	92·7	5	5·2	2	2·1	..	..	7	7·3	..

N.B.—Average life of all untreated posts is 3·3 years.

* Extracts from U.S. Department of Agriculture, Forest Products Laboratory, Madison No. R1757, Table 1 (1950).

MADRAS FOREST COLLEGE, COIMBATORE
CONVOCATION – JULY, 1952

The annual convocation of the Madras Forest College, Coimbatore was held on the 2nd July, 1952 at 3 : 30 P.M. Shri B. Ramkrishna Rao, B.A., LL.B., Chief Minister of Hyderabad-Deccan presided and presented the certificates and prizes. The Chief Minister accompanied by Shri Daulat Rai, Chief Conservator of Forests, Hyderabad, arrived Coimbatore from Hyderabad by air at 10 : 20 A.M. on the day, and was received by Shri M. D. Chaturvedi, Inspector-General of Forests, New Delhi, Shri C. R. Ranganathan, President, Forest Research Institute and Colleges, Dehra Dun and Shri K. L. Aggarwal, Director of Forest Education, Forest Research Institute and Colleges, Shri Y. M. L. Sharma, Principal and Shri M. Kesavan Unni Nayar, Chief Conservator of Forests, Madras.

The Chief Minister, accompanied by the Principal, arrived at the College exactly at 3 : 25 P.M. to preside over the function. He was received by Inspector-General of Forests, President, Forest Research Institute and Colleges, Director of Forest Education and Chief Conservator of Forests, Madras and other high officials.

After inspection of the Guard of Honour with the Principal and Shri M. V. Achar, smartly presented by the Ranger students, and introduction to other officers of the College, the Chief Minister was conducted to the gaily decorated convocation hall in procession accompanied by the Inspector-General of Forests, President, Forest Research Institute and Colleges, Director of Forest Education, and Principal, Madras Forest College, and Chief Conservators of Forests, Madras and Hyderabad. The portrait of the Father of the Nation above the seat of the Chief Guest added colour to the function. Amidst colourful scenes, the President, Forest Research Institute and Colleges, welcomed the Chief Minister with the following words :—

Shri Ramkrishna Rao, Ladies and Gentlemen,

"I have great pleasure in opening the proceedings of this convocation by first extending to you all a warm welcome. It is my pleasant duty to welcome to our midst to-day our chief guest Shri Ramkrishna Rao, the Chief Minister of Hyderabad State. Last year the convocation was honoured by the presence of the illustrious head of a neighbour State, His Highness the Maharaja of Mysore. To-day we are fortunate in having with us the distinguished chief of the government of another neighbour State. I know it has not been easy for Shri Ramkrishna Rao to tear himself away from his many preoccupations in his State even for the brief period that he is going to be with us. We have had to alter the date of this convocation in order to fit in with his many duties. We deeply appreciate his kindness and his interest in forestry which have prompted him to accept this engagement, despite much personal inconvenience.

"I think it is a fair description to say that the Forest Services of India rank among its most silent services. It is probably true that a good service, like a good child, should be seen and not heard. But the special handicap of the forest services is that not only are their members rarely heard, but they and their works are even more rarely seen by the public. I do not overlook the fact that the errors and short-comings of individual forest officers occasionally figure in an unpleasnt light, but the work of the forest service as a whole is remote and unspectacular and hardly ever takes the public eye or wins public approbation.

"There are, of course, several reasons for this state of affairs. India's forests are like India's cows – venerated but neglected ; but while in the case of the cow neglect has led to a vast multiplication of half-starved, unfit animals, it has, in the case of the forest, led to its

continued destruction directly by the axe or fire or indirectly by overgrazing and over-use, that is, by abuse. It is one of the queer contradictions of our national life that we regard the forest as closely bound up with our spiritual and cultural heritage, as the home of the *rishis* and the resort of the seeker after God, but do not hesitate to denude and devastate it and to subject it to all manner of abuse and ill-treatment. For several centuries the forests of India have been in a state of retreat bordering here and there on a rout. But for the wisdom of the British administration which reserved large tracts of wood lands not yet broken up for cultivation under the Forest Act, we should have had hardly any forests worth the name now left. In the main our forests now occupy hilly regions which are, as a rule, far from towns and intensively cultivated areas. It is consequently possible to travel extensively by rail or road in India without passing through a forest. Many millions of people live and die in India without ever having seen a forest or a wild animal in its natural haunts. Except for a microscopic minority, our educated citizens, our lawyers, doctors, engineers, legislators including ministers have never been, and have not the slightest desire to go, inside a forest even for a holiday. All this is in sharp contrast to the state of affairs in Europe and America where the forest attracts many millions of visitors seeking rest, recreation or sport.

"It is, therefore, not surprising that the strangest popular misconceptions prevail about forests and forestry. They range from romantic delusions of inexhaustible many-storied tropical forests teeming with dangerous fauna to pseudo-economic theories which view the forest as a reserve of land awaiting conversion to more profitable uses. Many people regard the forest officer as a superfluous and oppressive intermediary between a bountiful nature and the public. Much of all this is just plain nonsense, but the fact that such views are widely held is proof that public opinion, in particular the opinion of the intelligentsia, is grossly uninstructed as regards the truth about India's forests and forestry and the value and function of forests as productive and protective agents.

"I do not propose to take up your time in rebutting these false views. The truth about these important matters has been effectively told in the recent Government of India Resolution dealing with the new national forest policy. But a statement of policy, however, lofty its aim and noble its language is ineffective, unless it is implemented. And it cannot be implemented without popular support, especially in our new democratic order. The main problem facing Indian forestry is thus to win popular interest and public co-operation.

"I have referred to one difficulty which is peculiar to Indian conditions, namely, lack of contact between the people and the forests and want of appreciation of the aesthetic and material satisfactions that the forest can bring to the people. The second difficulty is inherent in the nature of forestry itself. The preservation of forests and the pursuit of forestry inevitably imply the restriction of the rights of user of the local population for the sake of the general public and of the present generation for the sake of future generations. The role of the forest officer is much the same as that of the man in a picture in Punch who said to his friend "Let us go and see what the children are doing and stop it". The forest officer is for ever going to see what the people are doing in the forest and stopping it. This is not a role calculated to endear him to the public. But it is an unpleasant duty which must be performed if the forests are to be preserved and protected for the service of future generations.

"This College as well as the Colleges at Dehra Dun, teaches forestry students how to manage forests and how to comport themselves as trustees of the nation's forests in relation to the public. But it is not so simple to educate the public to appreciate the value of our forests and to observe restraint and moderation in its use of the forest. This is a tremendous task in which the entire apparatus of public instruction – books, talks, the cinema, the radio, posters, journals, etc. – will have to be used. I never miss an opportunity of placing the

forestry point of view before an enlightened audience, if I can find a colourable excuse for doing so. The voice of the forest officer is too often a cry in the wilderness – which, in a sense, is perhaps as it should be, because after all he is a worker in the wilderness. That is my excuse for using the present occasion to put in a plea for forestry.

"Before I ask the Principal to present his report, I should like to wish the students passing out to-day the best of luck in their future careers and the happiness that comes from important work well done".

The messages received from the Ministers of Union and State Governments, and other dignitaries were also read out by the President. The message of Shri Rafi Ahmed Kidwai, Minister of Food and Agriculture, Government of India was as follows :—

"I regret very much that my parliamentary duties and my preoccupations with the country's food problems prevent me from taking part in the convocation of the Madras Forest College. I am, however, glad that the convocation address is to be delivered by my old friend Shri Ramkrishna Rao, the distinguished Chief Minister of Hyderabad. While I am busy wrestling with physical food problems, I have no doubt that his address will contain much food for thought on the forestry front. I wish the proceedings all success and, in particular, I wish the outgoing students a career of usefulness to the country and happiness to themselves".

The Principal, Madras Forest College, Shri Y. M. L. Sharma next presented the annual report and then announced the results.

Mr. President, Ladies and Gentlemen,

"I beg leave to present my report on the working of the College during 1951–52. The Madras Forest College continued to work under the Government of India during the year. Since transfer to the centre in 1948, 151 Rangers and 54 Officers passed out of the College. We are sending out to-day to the various Indian States, Ceylon and British Guiana, 30 trained Rangers.

Strength of the College—The total number of students in the College during the year was 64.

(*i*) *Senior Class* (*1950–52 Course*)—There were 30 students on rolls at the commencement of the year deputed by the following States :—

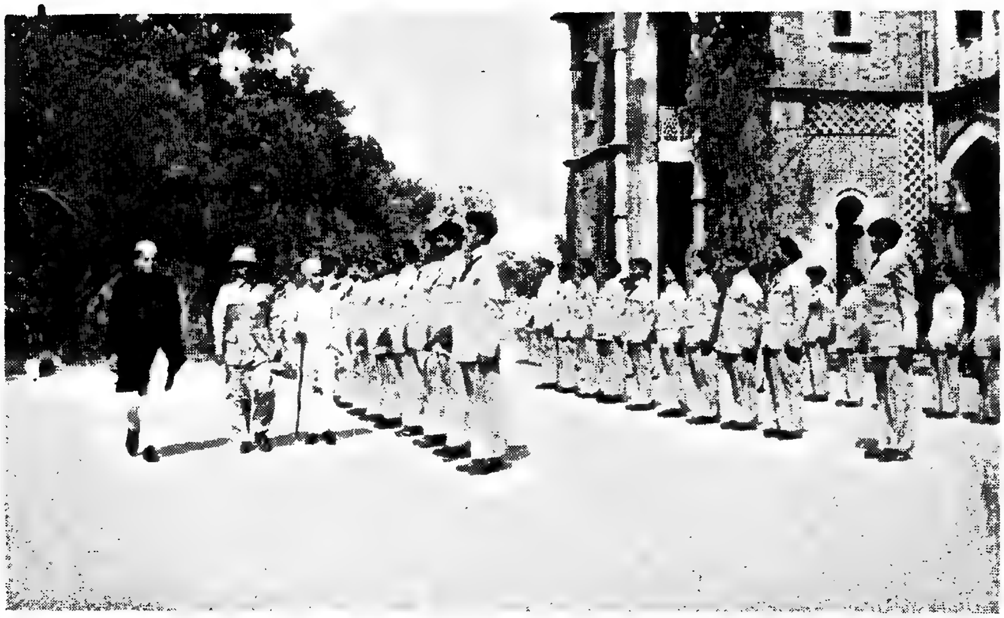
Madras	20
Hyderabad	5
Ceylon	4
Cultural scholar from British Guiana sponsored by the Ministry of Education, Government of India	1
Total	30

(*ii*) *Junior Class* (*1951–53 Course*)—35 students joined in July, 1951 deputed by the following States :—

Madras	20
Hyderabad	8
Ceylon	4
Coorg	1
Vindhya Pradesh	2
Total	35

One of these candidates from Madras resigned his seat early in July. The strength of the Junior Class thus remained 34 during the year.

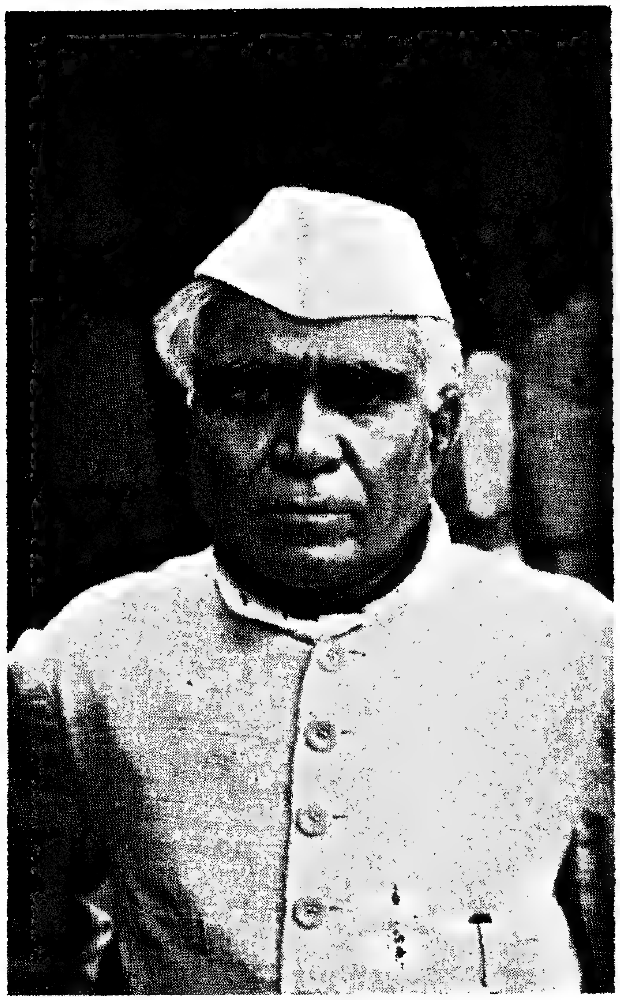
"*Courses of study*—The courses of study are on approved lines conforming to those of Dehra Dun with slight modifications in touring seasons to suit local conditions. Emphasis is laid on the practical aspect of the training.



Inspection of the Guard of Honour presented by Ranger students.

Shri B. Ramakrishna Rao, Chief Minister, Hyderabad State, delivering the address at the Convocation on 2-7-1952.

Left to Right :—Shri K. L. Aggarwal; Shri M. D. Chaturvedi; Shri B. Ramakrishna Rao; Shri D. Rai; Shri C. R. Ranganathan and Shri Y. M. L. Sharma.



Shri B. Ramakrishna Rao, Chief Minister of Hyderabad State who presided over the Convocation of the Madras Forest College on 2-7-1952 at Coimbatore.

" Saturdays at headquarters are either devoted to field work in the College nursery and estate, or to visits to places of forestry interest, in and around Coimbatore.

" *Tours*—The Senior Division toured in the divisions of Bangalore, Mysore, Nilambur, Nilgiris, North Chanda, South Chanda and Balaghat divisions. The junior class toured in North Coimbatore, South Coimbatore, Palghat, South Kanara, Wynaad, Tiruchirapalli and Madurai West divisions, during the year. A variety of problems was studied and practical work done on these tours.

" I thank the Chief Conservators of Forests, Madras, Mysore, Madhya Pradesh and Travancore-Cochin for permitting our tours in their respective jurisdictions. I have also to record my gratitude to the various Divisional Forest Officers and their staff for the co-operation extended to the classes on all their tours. I am indebted to the staff of the Southern and Central Railway, the Regional Transport Officers of Coimbatore and Calicut, and the various transport companies for their ready and unfailing co-operation extended to us without which these tours which form the basis of forestry training would have been difficult to complete.

" *Training in Field Engineering and Marksmanship*—All the 30 students who are passing out to-day underwent a course in Field Engineering and Marksmanship with various types of weapons extending over 3 weeks with the Headquarters Corps of Engineers at Bangalore. I am grateful to the Commandant and his officers for the splendid facilities afforded to the class.

" I congratulate W. M. Mendis who won the Principal's prize for Marksmanship with rifle and revolver, and H. V. Perera for winning the 2nd prize donated by the Assistant Lecturer in Engineering. These prizes were distributed to the two recipients by the Commandant, Col. Shumshere Singh, at a social evening in Bangalore.

" *Physical training* —Compulsory physical training and games at headquarters have contributed in no small measure to the general maintenance of good health and physique amongst the students.

" I am greatly indebted to Shri K. Kurup, Retired Judge, Coimbatore for his very keen enthusiasm and love for our method of training. He has donated a prize for the most physically fit and the healthiest student of the year. His offer has been gratefully accepted and I am glad to announce that the prize has been won by P. Ramakrishnaiya (Madras). He has neither visited the Medical Officer, Lawley Road dispensary on account of ill-health nor has he absented himself from classes either at headquarters or on tours, on any day and thus has cent-per-cent attendance.

"*Games and Sports*—Though keen interest and a good standard has been maintained in different games, I have to call upon the new entrants and the present students to endeavour and further improve the general proficiency in games during the coming year.

" The annual seven mile marathon race was run during March, 1952. P. Ponniah (Madras) won the Mannarghat Mopil Nair cup by running first in the race and completing the track in 45 minutes and 58 seconds. In this connection, I specially mention here the keen enthusiasm evinced by the 12-year old young Chaman Laungani (son of Shri V. M. Laungani, an officer of the College) who also ran this Marathon race and completed the track well ahead of the specified time limit of 70 minutes. He has been awarded a consolation prize – a silver cup – donated by the Principal.

" The annual athletic sports were held during November, 1951. The Richmond cup for the highest number of points scored in the annual athletic sports, as the champion athlete of the year has been won by A. K. Nair and the Pentland Shield as all-round sportsman by S. Radhakrishnamurthy both from Madras.

" The sports pavilion which contains just two rooms now is very small. Thanks to the Chief Conservator of Forests, Madras, who was pleased to order recently the grant of free timber, the Athletic Club has planned to put up a verandah on each of the Northern and Southern sides of the pavilion. This would increase the space and general efficiency of the pavilion.

" *Common Mess*—The Common Mess, which is a characteristic feature of the Forest Colleges, continued to run efficiently promoting a spirit of tolerance and mutual understanding among the students.

" The Rangers Mess was, earlier in the year, shifted to the building, formerly used by the Officers Class. The old Rangers Mess would now be used to serve as the mess for the Regional School of Foresters.

" *Extra-curricular activities – First Aid*—All the outgoing students attended a course of lectures in First Aid. The successful students in the First aid examination are awarded the certificates of St John Ambulance Association. I am grateful to the Medical Officer, Capt. Madhavan Nair, Lawley Road Dispensary and Shri P. K. Raghava Warriar, Medical Officer who examined the students and Shri Balasubramaniam, District Medical Officer, Coimbatore for the assistance given in this behalf.

" *Wild-Life preservation*—The outgoing students attended a course of lectures on wild-life last year. They also visited during this year the Mudumalai sanctuary in Madras, the Bandipur Sanctuary in Mysore and

the Khana-Khisli Sanctuary in Madhya Pradesh; they learnt details of maintenance of sanctuaries, and tiger blocks, besides organization of shikar and methods of capture and training of elephants. The Junior Division visited the Periyar sanctuary in Travancore during the year.

"*Audio-visual aid*—Regular exhibition of sound and silent films of educational value loaned by the different Information Services in India, the Forest Research Institute and Colleges. The F.A.O. and Burma Shell, is an important feature in the College as visual aid in scientific education.

"*Students' Literary and Library Club*—A number of new books were added on to the library during the year. An innovation to have a small film library of their own was decided by the members, of the literary and library club, and a 16 m.m. cine Kodak Camera was purchased. Some aspects of the tour of the Senior Division, who are passing out to-day, in Madhya Pradesh and Madras Forests were filmed. The club has proposed to have a complete record of forestry training, and Indian Forest operations for purposes of visual aid in education and promotion of forest sense among the public as well.

" The literary and library club also added on a mike for use on several important occasions in the Club and the College.

"*The College Magazine*—The Madras Forest College magazine is now entering its fifth year since its revival as a quarterly publication; it continued to maintain a high standard. We are glad to place before you to-day our July issue devoted to information on *Softwoods in Indian Forests*. We are obliged for the co-operation extended to us by the officers who contributed articles for this interesting publication. I have also to record my appreciation at the good work turned out by the Editor, Srinivasa Sarma, and the Business Superintendent, Shri T. R. Somasundaram, in the publication of the magazine.

" I have to earnestly appeal, in this connection, to the heads of Forest Departments of States to kindly order the supply of a copy of our magazine to each of their divisions. The annual subscription is only Rs. 6 for the four issues and that would not only give a great impetus for the magazine's wider circulation but would also stabilize its financial position.

"*The College Estate*—On 1st July, 1951, His Highness, the Rajpramukh of Mysore inaugurated the Second Vana Mahotsava festival followed simultaneously by planting of saplings in the College campus by all the officers, ladies and children assembled on the occasion. This was continued further, and a large bare area of over 16 acres in front of the College and the hostel compounds were planted up by the students. I am glad to say that there have been very few casualities. It is proposed to tackle an equally large area for planting this year during the rains. I am grateful, in this connection, to Shri Samtani of Jayem's Engineering Co., Coimbatore for the ready co-operation he extended to me in sparing his tractor to plough up the large area selected for planting this year and opening a number of experimental plots. All other operations connected with planting are done by the students as part of their training programme.

" The College estate has during the year been fenced with barbed wire, on the western, northern and eastern sides. I am again grateful to the Chief Conservator of Forests, Madras for readily ordering supply of 500 fence posts of teak, free of cost from Topslip out of the top ends of thinned poles; but for which the erection of such a fence so essential for protection of the College estate, nurseries and experimental plots would not have been possible.

"*Nursery*—A permanent nursery in front of the College, was newly started this year, to serve as a training ground for the students, to supply sufficient planting material of locally important species to plant up in the College estate and for free supply of seedlings to the public.

"*Rain Gauge*—A new rain gauge was installed in the estate earlier in the year as it was an absolute necessity.

"*Gass Forest Museum*—The replenishing of the museum is in progress. May I here, appeal to the forest officers and other interested public personnel also not to forget the existence of the Gass Forest Museum? It is the only one of its kind in South India and is a source of very considerable interest to the public and it has an obvious educational value to all. But it must be kept up-to-date and attractive. I confess to the feeling myself when I enter that most of the exhibits have been there a very long time and require replenishing. When specimens of interest are sent from divisions to the Forest Research Institute and Colleges, Dehra Dun, it is often quite a simple matter to send a similar one to the Gass Forest Museum.

" During the current year we have been able to add on several photographs and new specimens to the museum and its herbarium. I am grateful to Shri V. S. Kuppuswami, I.F.S., Conservator of Forests, Coimbatore Circle, for his magnificent gift of a very large number of botanical collections to our herbarium made a month ago. I also thank the Chief Conservators of Forests of Madras, Mysore, Bombay, Madhya Pradesh, East Punjab, Uttar Pradesh, Conservator-General, West Bengal, for readily responding to my request for despatch of special sized timber samples to the museum.

"*Training of cultural scholars from abroad*—We are sending out to-day the first cultural scholar from the College. He hails from British Guiana and deputed to the College under the scheme sponsored by the Ministry of Education. I hope he has derived the maximum benefit by his stay in this College during the

last two years and that he will endeavour to promote and maintain the ties of friendship he has made in this country, and between the two countries at large.

"*Visit of important personnel*—Shri K. M. Munshi, Shri A. B. Shetty, Dr. and Shrimati Naganna Gowd, Professor and Mrs. H. G. Champion of Oxford, were some of the distinguished visitors to the College and the museum during the year. Two officers from Thailand also visited the College and the museum during their tour of the country.

"*Staff*—Consequent on the reduction in the number of classes from 1st July, 1951 there was reduction in the personnel of the College – gazetted as well as non-gazetted. During the year there was only one further change in the staff. Shri D. P. Nagdev, Assistant Instructor was transferred to Ajmer to take up an appointment as Assistant Divisional Forest Officer. Both Shri and Shrimati Nagdev were very social amongst their colleagues and students. We miss in their absence two good people. We wish them, however, long life and happiness wherever they are.

"I also take this opportunity to convey my grateful thanks to all my staff in the College who co operated with me most loyally in the successful working of the College during the year.

"*Regional School* The Regional School for training of foresters has been sanctioned and arrangements are under way to start the school during this month. States like Travancore-Cochin, Mysore and Madras are participating this year in the scheme. The course extends over a period of one year. It is hoped that this important scheme will be carried through on a wider scale and other States of Peninsular India would also participate in this scheme and standardization of forestry training and maintenance of *espirit de corps* among the personnel.

"*Research*—I am again to urge that similar to the starting of a Regional School for foresters, the establishment of a research section to deal with problems of entomological, mycological and pedological importance affecting South Indian Forests is also long over due. Research being an important item in national reconstruction, I am confident that the Government will favourably consider the creation of the three research branches as an adjunct to the College, under the control of Forest Research Institute and Colleges, Dehra Dun. That would forge ahead by another step the cause of forestry.

"*Examinations and Results* —Examinations were as usual conducted half-yearly, annually, on each tour, and finally at the end of the course. External examiners were appointed, for the first year and final examinations. I am grateful to all these officers for serving as examiners amidst their multifarious duties.

"*Results*—30 students appeared for the final examination. I am glad to announce that out of these 30 students, *one* has qualified himself for the award of Honours Certificate, and all the remaining *twenty-nine* for the Higher Standard Certificates.

"*Conclusion*—Lastly with your permission, Sir, I should like to address a few words of advice to the outgoing students on behalf of my staff and myself.

"Let me congratulate you on choosing a career which above all others brings you nearest to nature. It is, therefore, the best. Treat the forest wealth of the country as your special trust. In order to derive the greatest benefit, interest and pleasure from it, I would advice you to acquire a hobby, which takes you into the forest, and which draws you constantly to it. There is no dearth of such hobbies from which you may choose. It is to some extent a disadvantage of your profession that while you see the results of the good work of your predecessors you may not remain long enough in the department to see the fruits conferred by the work which you do. You should bear in mind that you form part of an organization which has now great traditions of good work well done and you should endeavour hard to carry on those traditions to the best of your ability. You have before you a life, arduous, often lonely and unhealthy, but full of interest and delight given only to those who dwell in close contact with nature. Maintain the regular habits you have cultivated during the two years of your life in this institution and it will keep you off from ill-health, improve your general being, and promote longevity.

"I should like to ask you who will now be scattered all over the country, and others outside our Republic to keep a warm place of pride in your hearts for your *alma mater* and the friends you have made here. The College magazine is a medium through which the past and present students can keep in touch and it is always gratifying to see in the magazine matter emanating from our past students.

"I have no doubt that you will always keep before you the traditions of your service. Your important duty in the years to come will not only be administration of forests as have been taught here, but also the task of teaching the common man the love for trees and make him feel that forests are ultimately intended for his own benefit, for the benefit of his agricultural operations, for the benefit of his own cattle, and the country at large.

"I will now wish you all the best of health, happiness and success in your future career.

"I now request you, Sir, kindly to distribute the certificates and prizes".

JAI HIND

FINAL RESULTS

1950–52 RANGERS COURSE

Serial No.	Name of Student	State	Serial No.	Name of Student	State
In order of merit—			12	W. M. Mendis	Ceylon
			13	A. Thamburaj	Madras
HONOURS—			14	A. Kunhiraman Nair	Madras
1	R. Venkataramana Rao	Madras	15	G. Samuel	Madras
			16	S. Chandrapal	Madras
HIGHER STANDARD—			17	K. Subramaniam	Madras
			18	P. Ramakrishniah	Madras
2	S. Srinivasa Sarma	Madras	19	B. Ramakrishna Rao	Hyderabad
3	Lala Lajpat Rai	Cultural Scholar from British Guiana	20	D. Manik Prabhu	Hyderabad
			21	C. Damodar Reddy	Hyderabad
			22	B. K. Anjaneyalu	Madras
4	H. R. Pieries	Ceylon	23	Y. S. Bhaskaracharyulu	Madras
5	V. Rangamani	Madras	24	P. Ponniah	Madras
6	B. Venkatnarayan	Hyderabad	25	H. V. Perera	Ceylon
7	Y. V. Hanumantha Rao	Madras	26	S. Magdum Hussain	Madras
8	K. Lakshman Singh	Madras	27	K. C. Chandrasekharan	Madras
9	S. Radhakrishnamurthy	Madras	28	K. Ramappa	Madras
10	M. Chackradhar	Hyderabad	29	S. Wickramasinghe	Ceylon
11	B. V. Subbiah	Madras	30	A. Venkat Rao	Madras

LIST OF PRIZE WINNERS

1950–52 RANGERS COURSE

Serial No.	Name of prize	Name of recipient
1	HONOURS GOLD PLATED SILVER MEDAL—awarded by Government to the best student in the class, obtaining the highest number of marks in the aggregate and also Honours certificate.	R. Vankataramana Rao (Madras).
2	COLLEGE SILVER MEDAL—awarded to the best student in Forest Utilization.	S. Srinivasa Sarma (Madras).
3	COLLEGE SILVER MEDAL—awarded to the best student in Forest Botany.	R. Venkataramana Rao (Madras).
4	COLLEGE SILVER MEDAL—awarded to the best student in Range Administration.	S. Srinivasa Sarma (Madras).
5	THE CAMPBELL WALKER PRIZE—awarded to the best student in Forestry.	S. Srinivasa Sarma (Madras).
6	THE BRASIER PRIZE—awarded to the student likely to become the best outdoor Ranger.	W. M. Mendis (Ceylon).
7	THE LODGE PRIZE—awarded to the best student in Forest Engineering.	Lala Lajpat Rai (Cultural Scholar from British Guiana).

SPORTS AND ATHLETICS

1	THE RICHMOND CUP for the best sport Athlete ..	A. K. NAIR (Madras) (Senior Division).
2	THE MANNARGHAT MOOPIL NAIR CUP for Marathon race (cross country race) run over a distance of 7 miles	
	First	P. PONNIAH (Madras) (Senior Division).
	Second	K. RAMANKUTTY NAIR (Madras) (Junior Division).
	Third	M. P. BELLIAPPA (Coorg) (Junior Division).
	PRINCIPAL'S CONSOLATION PRIZE awarded for running Marathon race	CHAMAN LAUNGANI.
3	THE FISCHER CUP for *Tennis Singles*	
	Winner	W. M. MENDIS (Ceylon) (Senior Division).
	Runner up	A. VENKAT RAO (Madras) (Senior Division).
4	*Tennis Doubles*	
	Winner	A. VENKAT RAO and S. WICKREMASINGHE.
	Runner up	B. VENKATNARAYAN and K. SUBRAMANYAM.
5	THE PENTLAND SHIELD for the best all-round sportsman in the College during 1951–52	S. RADHAKRISHNAMURTHI (Madras). (Senior Division).
6	AMIRMUHMAD KHAN CUP for the best all-round division	(Junior Division).
7	COWLEY BROWN CUP for inter-division Hockey ..	(Junior Division).
8	MUMTAZ CUP for inter-divisional Cricket	(Senior Division).
9	UBEROI CUP for inter-divisional Volley Ball ..	(Junior Division).
10	VIRA PAMBHOI CUP for inter-divisional Foot Ball ..	(Senior Division).
11	HEALTHIEST STUDENT PRIZE awarded by Shri K. M. K Kurup, Retired Judge, Coimbatore, to the College during the year.	[P. RAMAKRISHNIAH (Madras) (Senior Division)].

The Chief Minister then distributed the certificates and prizes to the various recipients and then delivered the convocation address which was heard with rapt attention.

Shri Ranganathan, Ladies and Gentlemen and Graduates of the year,

"It is a matter of great pleasure to me to have been asked to preside over to-day's function, attended by so distinguished a gathering, including experts and technicians, and to give away certificates, and prizes to the students of the Madras Forest College, who are completing to-day a strenuous course of a two-year training. I am fully conscious of my shortcomings ; and being merely a lawyer and a politician, I claim, however, no more than a nodding acquaintance with the trends of Forest administration, the broad outlines of its development and the importance of forest wealth in India's economy. It is, therefore, with mixed feeling of diffidence and gratefulness that I choose to address you this evening. I, however, consider it a signal honour to me to be associated with to-day's function and deliver the Convocation Address.

"I need hardly tell you that this great country of ours is primarily agricultural, and it is just now trying to build up its shattered economy. Agriculture and forestry form the backbone of India's rural life. The former, as you are aware, is the biggest industry of our country, and forestry comes next to it. The importance of forests and forestry is specially great in a country as ours, where agriculture is the primary occupation of a majority of its population.

"Forests have played an important part in the history of our nation. They inspired our sages and saints in the dawn of our civilization. Nay, our ancient and hoary literature

and culture had their birth and reached their efflorescence in the sanctuaries of our sylvan glades. Epics like Ramayana and Mahabharata were composed within the green solitudes of Vindhyas and Himalayas, while our great men and heroes wove poetry and philosphy, romance and history in the serene quictude of our hills and woods.

"Forests are the national assests of a country. They provide us with innumerable products so essential and indispensable for our domestic life as well as for industrial expansion. I do not think it necessary on this occasion to touch upon the direct and indirect benefits of forests to humanity and the economy of a country. They are undeniably great and hence the essential need for an immensity of forest wealth. It is only too true that we do not possess it in such abundance as we desire. Our resources are poor. The total forest area in India, taken as a whole, comes only to roughly 22 per cent, or about 1/5th of the total area of the country while the accepted minimum for a prosperous and balanced economy on a national level is 25 per cent to 33 per cent, i.e., 1/4th to 1/3rd of the total area. A detailed study of the statistics would show that these forests are not evenly distributed as they should, but are mostly concentrated in certain States, as Andamans, Assam, Madras, Uttar Pradesh, etc., while other States fall far behind in this connection. My own State is one such, where forests cover about 15·5 per cent of its total area. Here again forests are mainly concentrated in the eastern side comprising Telangana districts, while all the districts of Marathwada and Karnatak have only about 5 per cent of their area covered with forests, and that too of a very poor type. The most important of our tasks should be to put to use, to the fullest extent, the resources available out of our forests on the one hand, and to create forests in such a way as to make them evenly distributed over the entire country on the other, so that all parts and all sections of our country-men could benefit from them.

"Short as our forest resources are, it stands to reason that this sacred treasure entrusted to us, should be preserved and conserved. People seldom realise this outstanding truth, and destroy this national wealth in an unpardonably negligent manner. They fail to understand that our forests can be compared to one's bank balance, which, if not judiciously used, would shrink and ultimately exhaust, however, great it may be. It is, therefore, essential that this national wealth should be controlled and managed by Government. However, trained and qualified individuals may be, they cannot have either the broad outlook or the great resources which a Government can command. In fact, individual owners have tried to cash their assets either blissfully ignorant of or callously indifferent to the effects of the denudation of forests on the country as a whole. Taking the example of my own State, I can say that wooded lands, belonging to private persons, are being cleared of tree-cover every day. It is common knowledge that vast areas, even inside Government forests are being brought under the axe in almost all the States of India, under one pretext or another. It is unfortunate that such anti-economic clearance of forests should take place under the garb of "Grow More Food", or to satisfy the land-hunger of the land-less peasantry of the country. The solution of our food problem, to my mind, lies in the correct utilization of land and in its intensive cultivation in a systematic manner based on modern scientific methods. I, therefore, consider it necessary to clear the misconception which some people do have that agriculture is more important than pasture and pasture than forest. Such an attitude should be given up once for all. Their relative order of importance of priority is not what matters, but an understanding of their inter-dependence, and it must be realized that all of them together form a close nexus on which human life and prosperity depend. The neglect of one inevitably damages the other. In short, balanced and productive land utilization is the foundation of national prosperity. All available land in our country should be reallotted to that form of use under which it would produce most and deteriorate least. It is not an easy task, nor can it be solved overnight, but requires constant, continuous, hard and earnest endeavours from one and all. I am glad to be able to say that this tremendous, but nevertheless important work, has not been neglected by

our generation. The Government of India has laid considerable stress on this aspect of land use in its recent enunciation of India's National Forest Policy, which, I am sure, all of you must have known by now. I might tell you that some of the States have gone ahead and have already constituted Land Management Boards which, in spite of various handicaps, are doing fundamental and basic work, the effects of which could be felt or measured only after the lapse of considerable time. The Government of my State is also considering the creation of a high power "Land Management and Utilization Board", which undoubtedly would go into the details of this question. It is also possible that we might create a Land Management Circle, under the Forest Department, to translate the decisions and recommendations of this Board.

"Shri Ranganathan has very rightly referred to the tendency of the people at large to devastate the forest wealth of the country without hesitation and has correctly described it as one of the queer contradictions of our national life. We do regard the forests as closely bound up with our spiritual and cultural heritage and the ancient home of our *Rishis*. But I am afraid it is not surprising that we have lost the sylvan sense which our forefathers in ancient days, and even in recent historical age possessed, just as we have lost many other good qualities they possessed.

"Looking back to the olden days, I am reminded of our ancient literature which throws some light on the forest-consciousness of our forefathers. Our Puranas and all Prabandhas contain copious references to our forest wealth. Along with beautiful descriptions of the six *Ritus* (seasons), we find hundreds of varieties of forest trees enumerated in the Ramayana and the Mahabharata in the course of their description of Dandaka and Naimisa Aranyas (forests). There were three kinds or categories of forests that were consciously maintained. The first is the Udyana Vana which corresponds to our modern town or city park with extensive forest cover but mostly suited to make it a pleasure-resort. We find almost all the romantic literature of ancient India woven round these Udyanas. The second category appears to be the *Tapo-vanas* or the forest covered sanctuaries where the *Rishis* established their Ashramas – which gave full protection not only to the trees but also to the animal life. We have many instances where the kings fond of hunts and *shikar* strayed into these sanctuaries and violated the rules of non-violence and became the victims of the wrath of the *Rishis*. Even wild beasts, tigers and lions too were protected and it is only when man-eaters troubled the life of the Ashrams and the population around that the *Rishis* invited the kings to go on hunting expeditions. The love for trees, the care with which they were nurtured and the feeling of affection which they inspired in human beings, is most typically described by Kalidasa's Sakuntalam. Sakuntala is described as shedding tears while parting with saplings and plants and creepers she had watered with her own hands just as she did for her favourite deer. It is not, I am sure, altogether a poetic fancy ; it was a characteristic of our national life in those days. The third category was, I think, the Aranyas, the thick forests ; the bigger ones were called *Maharanyas*. I remember having read the names of hundreds of forest trees in the descriptions of Aranyas. *I wonder whether all of them are or can be identified.* It will not be surprising if many of them have not survived the ravages of the cruel process of denudation of forests which has resulted in the impoverishment of our national wealth.

"It is also true as Shri Ranganathan has said, that the functions of a forester have now degenerated almost to that of a policeman. He has to do the unpleasant job of guarding the forest from encroachment by the public – that has become his major job and that is why he is unpopular – not only unpopular but is almost always depicted as a source of annoyance to the people rather than as one who is performing a legitimate duty imposed by the State. Looking back again, I see that the Department of Forestry is no British innovation and not a result of any new fangled outlook of modern times. Even in ancient days, there used to be what were called *Vana palakas* (guardians of forests) whom the State employed for the purpose of

protection and improvement of forests. In fact, I found a small chapter on the Forest Department administration in Chanakya's Arthasasthra along with certain rules for controlling prices and combating blackmarketing and punishments for such culprits. My friend, the Inspector-General of Forests, need not be perturbed by any criticism that he or his Department is superfluous. Even in olden days there used to be a hierarchy of foresters and officers for the administration of forests.

"Even as regards public interest in forests, when we look back upon our old customs and practices, we will find at least two festivals – one in spring and one in winter directly connected with excursions into forests. Vana Mahotsavas or Vana Bhojanas or pic-nics formed a part of our life even till recently in my child-hood when life was not so hectic as it is to-day. This interest has to be consciously revived. It is this realization that inspired my respected friend Shri Munshi to start the campaign of Vana Mahotsava for which all forest-lovers should be grateful to him.

"Another problem which has, of late, assumed considerable importance is that of erosion. The indiscriminate extension of agriculture and consequent destruction of forests have not only deprived the local population of fuel and timber, but have also stripped the land of its natural defences against dust storms, hot devastating winds, and erosion. The role of forests in the national economy, both protective and productive, entitles forests to lay claim to an adequate share of land. Soil erosion in peninsular India is, perhaps, not so much of a spectacular phenomenon as it is in the Siwaliks and the outer Himalayas of the Punjab and the Uttar Pradesh. Nevertheless, the ravages of erosion can amply be noticed in the Western Ghats, the best example being Nilgiris, and the Deccan Plateau. The effects of erosion and destruction of forests are evident in the form of deterioration of productivity of the soil, and formation of arid areas and deserts. The Rajputana desert, which is said to be rapidly enlarging and engulfing further areas year by year, needs special mention in this connection. Strong winds that develop in this region during summer, transport vast quantities of sand and salt from the sea and the Runn of Cutch, whipping the desert into terrific dust storms, the fury of which is felt throughout the whole of North-West India. The Marathwada and Karnatak areas of my State are other examples where absence of forests is strongly felt. Laterization has taken place on vast areas. Top-soil has been washed off, exposing the hard subsoil and making it absolutely unfit for agriculture, resulting in near famine conditions. I am pleased to state that the Forest Department of my State has taken up this mighty challenge of Nature and have drawn up a scheme of afforestation and other anti-erosion works under the Five-Year Development Plan of the State. This scheme envisages an expenditure of Rs. 21·43 lacs over a period of five years and contemplates doing contour trenching, bunding, gully plugging and afforestation in compact patches in the districts of Bidar and Osmanabad, where erosion is at its height, at the rate of 2,500 acres every year. They have already rehabilitated about 3,650 acres so far. Your Inspector-General of Forests has recently visited this area and has congratulated the officers who have brought about a radical change in the soil cover during a brief period of less than 5 years. I am sure this useful work would be continued and the day would not be far off when this part of my State would be richly clad with forests. The Chief Conservator of Forests of my State has published a pamphlet regarding this work, copies of which he has brought with him for distribution to-day. He has also brought a few films regarding this work, which he would be only too glad to exhibit if you so desire.

"One of the great tasks that the foresters of to-day are called upon to perform is the rehabilitation of our denuded forests. The mistaken belief that forests grow by themselves and that they are public property and are, therefore, everybody's property and anybody is free to do what he likes, has led to the destruction of our already depleted forests. To crown it,

forests are supposed to be reserves of land, available for extension of agriculture whenever wanted, very often under the Grow More Food campaign. These ideas have led the common man to believe that the Forest Departments, with their paraphernalia of professional staff, forest laws, techniques, research and forest protection are nothing but enemies of the people. Forest officers are very often taken to be no more and no worthier than middlemen who have come between the producer and the consumer, to the detriment of the interests of the latter. Let me tell you that I consider these notions to be mere delusions arising from the ignorance of the common man and fanned by the greed found in human nature. Foresters are no less patriotic than the best of the patriots in our country. In fact they are entrusted with the great responsibility of being the trustees of the richest of our national resources which is essential in multifarious ways, and forms the basis of our economic and industrial life. They are, therefore, not only answerable to the present generation but also to the generations to come.

"Keeping this in view, many of the States, having as they do popular Governments, have taken over all private and Zamindari forests. In my own State all Jagirs have been abolished resulting in the taking over of Jagir forests in May, 1950. Prior to this absorption, the forest area of my State was about 9,624 square miles, or about 11 per cent. It has now risen to about 15·5 per cent, being about 12,822 square miles due to the amalgamation of about 2,915 square miles of Jagir forests. As I have already stated, individuals have tried to cash in the assets they possessed in the shape of forests resulting in the degeneration and diminution of the latter. It now remains for the present generation of foresters to improve and conserve denuded and depleted forests. Efforts are being made in my State to bring such forests under systematic and scientific management, which would lead to their rejuvenation. Working Plan parties have been strengthened to ensure that this work is completed in the shortest possible time. As you know, forestry, unlike agriculture, is a long-term enterprise, extending well beyond the average span of human life, requiring a continuity of policy and skilled management over a considerable length of time. Patient waiting is necessary before any tangible results can be achieved. I hope and pray that our labours in this connection would bear fruit. On the Forest College at Coimbatore, and its sister institution at Dehra Dun, devolve the responsibility of supplying the trained personnel required for the performance of this great task of husbanding our forest resources wisely and well.

"The Madras Forest College has a distinguished record of about 35 years of having served not only the Deccan region but also Ceylon. To date, the College has turned out close on 900 Forest Rangers, manning the personnel of forest departments all over India. The importance of this College lies in the fact that it deals with forest education on a regional basis. It concentrates on the needs of peninsular India, whose conditions are vastly different from those of the rest of the country. I understand soil conservation receives special attention and rightly so, in the curriculum of this College, so that the trainees of this College are sufficiently equipped to face the task ahead of them of rehabilitating the vast stretches of barren plains and bare hills of the Deccan. Some of the chrónic famine areas of our country are located in the Deccan and on the securing of a tree-cover on them will depend, to a great extent, the mitigation of famine conditions that have now become so common a feature of our economy. In this connection, I cannot but commend the *Vana Mahotsava* drive of Shri K. M. Munshi, as Union Minister for Forests, Food and Agriculture, which not only aims at creating tree-love and tree-consciousness among the common man, but also in raising trees wherever it is possible to do so.

"In the end, let me say that I have been very much impressed not only by the excellent standard of instruction maintained at this College, but also by the good physical standard attained by the outgoing officers. I earnestly hope that this institution will develop further and the students passing out from the College will be equal to the task ahead of them. One

particular aspect of the development of this institution deserves special notice. I have learnt with great satisfaction that a Regional Training Centre for Foresters is going to be instituted at this College. The need for the training of subordinate forest personnel can scarcely be emphasized. It is to be hoped that the adjoining States will take the fullest advantage of this new wing of the College. Local schools, however, efficiently run, are unable to develop a broad and integrated outlook and an *esprit de corps* among the field workers, to the extent possible in a combined regional institution. I hope that the scope of this College will be further extended in due course to include forest research, and that every effort will be made to develop it as the Dehra Dun of the South.

"Let me now congratulate you, the students, on succesfully completing your training. You have learnt here to work together and live together in a spirit of co-operation and I hope you will carry this torch of comradeship and helpfulness which has been lit here forward through your lives. You must expect to encounter difficulties and hardships, for the duties of a Forest Officer are multifarious, arduous and irksome, but you must not give way but prove yourselves worthy of the trust put in you. I hope you will be inspired by a passion to serve the people among whom your lot may be cast. However, great the intellectual, the academic and technical qualifications one may possess, the highest qualification one should have, is the spirit of service which, I dare say, you possess in its fullness and abundance. I wish you all godspeed and luck in the life you are entering to-day and earnestly hope you will prove worthy of the great institution to which you belong.

"Before concluding my address, permit me to thank my friend Shri Chaturvedi, the Inspector-General of Forests and your President, Shri Ranganathan, who kindly invited me to this function. I would be failing in my duty if I don't thank the Principal and staff of the College and all those who are present here to-day and have listened to me patiently all along".

JAI HIND

Shri M. D. Chaturvedi, Inspector-General of Forests, then proposed the Vote of Thanks, as follows:—

Principal Sharma, Fellow Workers, Ladies and Gentlemen,

"I deem it a great a privilege indeed to have this opportunity to express my gratitude to Shri Ramkrishna Rao, the Chief Minister of Hyderabad, for having spared himself to grace this occasion, and for the brilliant address he has delivered this afternoon.

"Shri Ramkrishna Rao needs no introduction. Shri Rao is a *mulki* having been born and bred and, shall I say, baked in Hyderabad and its prisons. He constituted the spearhead of the Congress organization and bore the brunt of a reactionary regime which is no more. It is typical of him that he bears no ill-will to those whom he fought, and against whom he won.

"I made his acquaintance during my last visit to Hyderabad where he commands the respect of all and sundry, of his admirers and adversaries alike. Generous to a fault, his lavish hospitality reminded me of the *takluf* of Lucknow and the *dastarkhwans* of the Nawab *vizirs* of Oudh.

"Used as I am to the punctual unpunctuality of the men of affairs these days, I was rather taken aback when Shri Ramkrishna Rao having fixed an appointment to see me at 10 A.M. actually called me in at 10. I must confess I was not prepared for the shock. During that interview we talked of many things. But, what left an indelible impression on my mind was his concern about the wholesole destruction of *mahua* trees by the tenants. He told me quite candidly his Government was unable to stop this mischief for he must honour an election pledge. It is an object lesson for election campaign for all time. He found it impossible to

save both face and the trees in the country-side. It is this trait of his character which endears the most casual visitor to him.

"There is one more matter we discussed that day. It is a matter which seems to occupy the attention of all Governments in the country to the exclusion of everything else. In whatever direction I go – north or south, I hear nothing else except a hysteric cry against corruption. Its echo resounds the lobbies of popular assemblies ; one reads of it in the press and hears of it from public platforms.

"Heads of States are reported to be concerned about nothing else except corruption. The story is told of a Minister who ordered his Chief Conservator of Forests to submit a list, if you please, of all his corrupt officers. His inability to obey the fiat was considered to be an indication of his shielding the miscreants. Another enthusiast is reported to have ordered the stay of all normal transfers, until he had an opportunity of going in the garb of a villager, *a la* Harun-ul-Rashid, and see for himself the goings on in forest guards' beats. Yet another is said to have ordered the transfer of everyone blissfully unconcerned about the costs involved in transfers.

"I mention these examples, I trust they are exaggerations, merely to illustrate how this bogey of corruption has warped the judgment and jaundiced the vision of those at the helm of affairs. The loss of perspective and lack of sense of proportion have cramped their style and clogged the wheels of progress. They imagine fondly that the revenue of a State would increase by stopping leaks, not by development.

"As was only to be expected, the malady has gone deeper. In their efforts to please their bosses, the heads of departments have also caught the infection. They have also become corruption-minded. They order enquiries, charge-sheet the subordinates on the least little suspicion and report their doings to their bosses in the hope of being patted on the back. Officers indulge in the comfortable pastimes of running one another down and reputations are glibly torn to shreds.

"I have been scratching my head and ransacking my brains for some time to find out the reason of all this smear campaign. Do you know that when a girl is not pretty they call her accomplished, charming, sweet, angelic, unsophisticated indeed by all the high sounding names to cover the lack of the most desirable quality among women, viz., beauty. Likewise, when a man is not clever, he resorts to the simple device of earning for himself a reputation of being honest. For, any fool can be honest; what is difficult is to be above suspicion. What is even more difficult is to have the gift to be able to grow two blades of grass where one grew before.

"Believe me this cry of corruption is a smoke screen to hide our lack of talent – a diversion to derail public opinion into fruitless channels. I who has put in 30 years of service can testify without any fear of contradiction that with the advent of Swarajya the so-called corruption has definitely decreased, not increased.

"I take this opportunity of raising my voice against this atmosphere of suspicion, mutual incrimination and callous calumnies. Such a state of affairs is not conducive to planned team work and development of our resources. People spend all their time in keeping themselves out of trouble. They dare not undertake anything new for fear of the risks involved.

"I appeal to you, Sir, to use your good offices in giving this bogey a decent burial and engender a spirit of mutual trust so necessary in rebuilding our economy.

"I turn to the officers present here and more particularly to the outgoing rangers to stand by me in fighting this bogey.

"I am afraid, I have left myself little time to fulfil the other more pleasant task assigned to me, viz., to give a few words of advice to the outgoing Rangers. The other day I came across an Arab Proverb which says never to give advice *in* a crowd. Mind you, it does not prohibit me from giving advice *to* a crowd. Please remember it is not what you do, but what you become by doing it which matters. Kabir became a sage weaving cloth ; Valmik turned a saint indulging in highway robberies. I was a little disappointed at your reaction, discernible in your variety show, to the task of digging pits assigned to you by your Principal. It is those alone who toil and soil their hands who have a chance on this earth and hope in heaven. Pointing to the navy blue suit of an Indian student who was under training at a Machine shop at Dusseldorf, his big boss in blue over-all and cotton waste in his hand told me, "This man will never be an Engineer ; look at his spotless suit". My advice to you is – do your job by becoming a part of it yourself. Do not worry about pay and prospects. Fortune smiles only on those who have no time to woo it. I wish you all God speed and a career filled with thrills of doing your best.

"Before I resume my seat let me thank you once again, sir, on behalf of everybody present here and on behalf of the Government of India for having taken the trouble to come here from the midst of your manifold activities.

"I should also like to take this opportunity of felicitating the Principal of this College, Mr. Sharma, and his staff for their splendid achievements which find reflection in the results of the College and excellent arrangements. I would also like to thank our other distinguished visitors more particularly the ladies for leading charm and colour to this ceremony".

JAI HIND

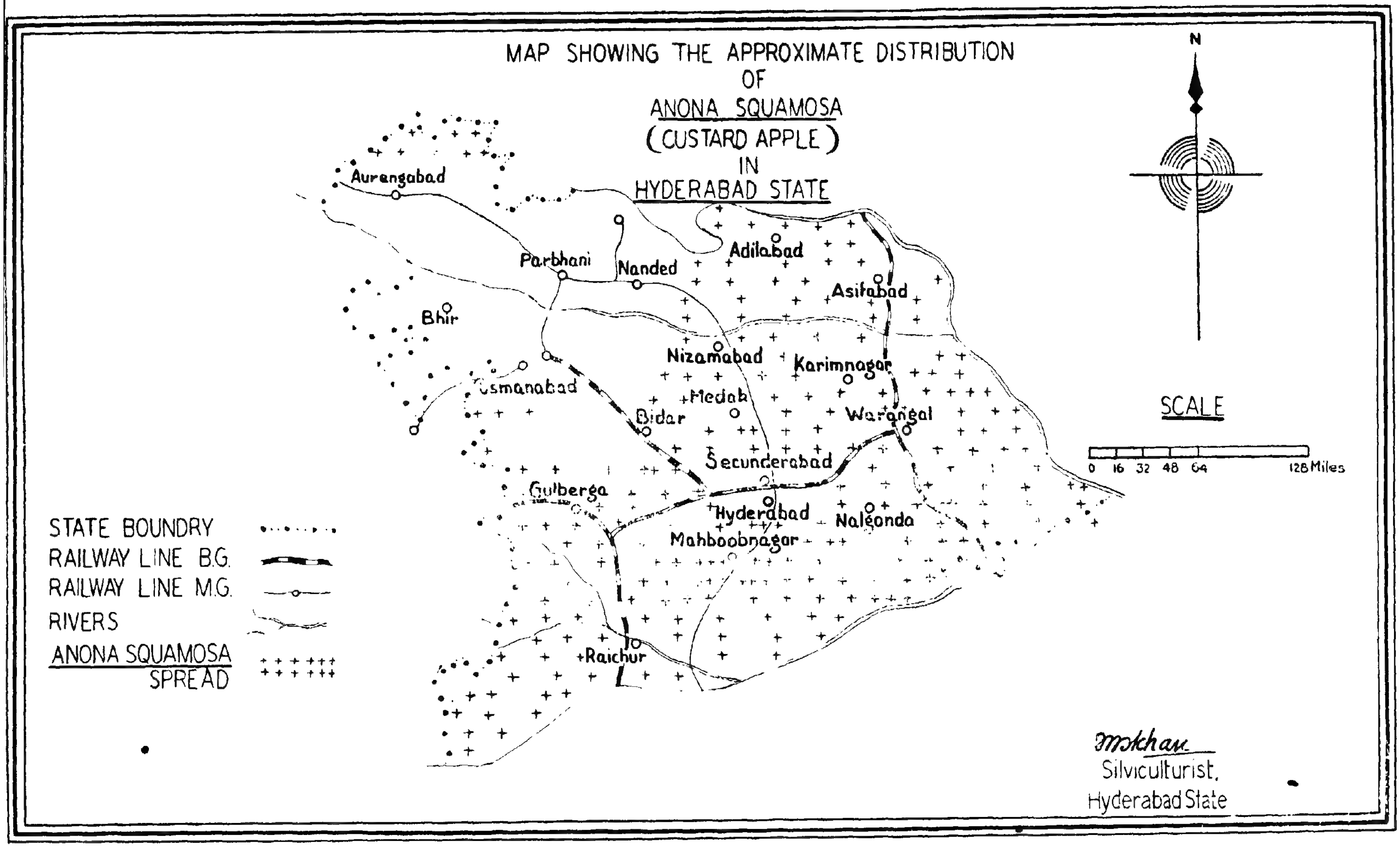
The function ended with the singing of the National Anthem by the passing out students of the Colleges.

On 3-7-52, the Chief Minister inaugurated the third Vana Mahotsava festival in the College estate amidst a large gathering of officers, students, ladies and children of the estate. One sapling of *Delonix regia* was planted by the Chief Minister in front of the Rangers Mess followed by planting of saplings of *neem* and *Gul mohur* by the Inspector-General of Forests, President, Forest Research Institute and Colleges, and distinguished guests. The Chief Minister then visited the Gass Forest Museum of the College, and evinced very keen interest in its collection.

↑ General view of the habitat of *Anona squamosa*.

(*Anona squamosa* plants growing in the crevices and pockets of boulders.

← Near view of *Anona squamosa* tree.


MAP SHOWING THE APPROXIMATE DISTRIBUTION
OF
ANONA SQUAMOSA
(CUSTARD APPLE)
IN
HYDERABAD STATE
N
SCALE
0 16 32 48 64 128 Miles
Aurangabad
Parbhani
Nanded
Adilabad
Asifabad
Bhir
Nizamabad
Karimnagar
Usmanabad
Medak
Bidar
Warangal
Secunderabad
Gulberga
Hyderabad
Nalgonda
Mahboobnagar
Raichur
STATE BOUNDRY
RAILWAY LINE B.G.
RAILWAY LINE M.G.
RIVERS
ANONA SQUAMOSA SPREAD
M.K.Khan
Silviculturist,
Hyderabad State

ANONA SQUAMOSA, LINN.

Vernacular names :—Sharifa, Sitaphal (Hindi), *Sitapalam* (Telugu), *Duranji* (Kanarese)

BY M. S. KHAN
Silviculturist

1. *Anona squamosa* is usually a large shrub sometimes assuming the size of a small tree in favourable localities. It is found growing gregariously in hilly tracts, waste lands, village hedges and in gardens. It is found practically in all the districts of Hyderabad State more so in the Telangana and Kernatic sides than in the Mahratwada. This species is suitable for covering denuded hills, stoney areas and blanks. The seeds and other parts of the tree are of economic and medicinal importance.

2. *Vegetative characteristic*—This is a small tree in its favourable localities but assumes bushy nature in hard stony areas. Bark is thin and grey. Leaves oblong-lanceolate, 2 to 4 inches by $\frac{3}{4}$ to 1 inch, pellucid dotted with a peculiar smell. Flowers are greenish, single or in pairs on pedicels as long as flowers, bracteate below the middle. Sepals minute triangular pubescent. Petals 6, in two series, pubescent on both surfaces. 3 exterior petals lanceolate, triquetrous, thick and fleshy, 1 inch long ; 3 interior minute or wanting. Stamens indefinite. Carpels united into a large fleshy fruit 2 to 4 inches in diameter. Seeds numerous, embedded in a soft pulp, oblong, brownish black.

3. *Habitat*—This species is found in hilly areas, stony soils in waste lands, village borders, hedges and in gardens. It was originally introduced from the West Indies in India and now it has naturalized itself and is commonly found in a wild condition all over the State. It is found in more abundance in the Telangana and Kernatic tracts of the State in granitic gneiss formations with sandy and gravelly soils. In the trappean area of the Mahratwada it is less common but comes up profusely with care and protection.

4. *Fruit*—Custard apple ripens in the cold season and comes out in the market from the middle of October till the end of January. Peak months for this fruit are November and December. Fruits from this State are generally exported to Bombay. They are available in the local market at a rate of Ans. 12 to Re. 1 per dozen. The best variety of fruit, famous for its largeness and sweetness of pulp with few seeds are from Mahboobnagar district.

5. *Uses to which the different parts of the plant are put to*—The tree is usually of a small size and the timber has no other value than fuel. The wood is soft, close grained, and weighs approximately 40 lbs. per cubic foot. Custard apple is reputed to be good for the digestion. Leaves, immature fruits and seeds contain a principle fatal to insects. The leaves are said to relieve pain and swelling, when applied to the affected parts. The seed powder mixed with gram flour is applied to head for getting rid of lice infection. The oil expressed from its seed after purification can be used as a substitute for linseed and other commercial oils in the manufacture of soaps, etc.

6. *Silvicultural characteristics*—This species is found growing on almost all types of soils as granitic gneiss, trappean formations, sandy loams and bouldery soils as well as in black cotton and heavy ones, generally in waste places in the villages, hedges of fields and in village grazing lands. Cattle, particularly goats generally devour all natural growth, but this species escapes their rapacity due to the pungent smelling ingredients found in the leaves and twigs. Although this species is not flourishing in the trappean areas of the Mahratwada, it comes up readily if protection from human interference in afforded. The scarcity of fuel in these areas, to my thinking, is the inhibiting factor in the spread of this species in Mahratwada tracts of

black cotton soils. The bushes are cut down and sold in bazar as fuel along with other bushy yield and this species thus has no chance of establishing itself and yield fruits.

7. *Artificial regeneration*.—The best results are obtained from direct sowing of ripe seeds *in situ* in ploughed line about 12 feet apart. It was successfully raised by this method in the trappean area of Aurangabad district round the ruins of Daulatabad Fort in 1946. This species is being extensively tried in the afforestation areas of Osmanabad Deccan Trap) and Bidar (granitic gneiss) where the soils are eroded and where (in Bidar) laterization is found in its different stages. The results are under observations. There are 78 seeds in an ounce, or 1,248 seeds per lb. This is a very good species for covering denuded hills, waste lands, and eroded bare grounds specially where the problem of grazing for acute, for this is not browsed either by cattle or goats.

8. *Garden cultivation*—The custard apple can be cultivated with much profit, under irrigation with proper manure. Experiments in grafting would no doubt produce good results as it has done in the case of mangoes, Guava and other tropical fruits. Seedlings are easily raised.

9. This important and economic species can be utilized in afforestation works along with other suitable species in the dry denuded hilly areas specially where the grazing is heavy and the protection from it is impracticable. It can be profitably grown for its fruit in gardens and its quality can be improved by grafting, etc.

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3. Gambles Indian timbers, page No. 22.
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A NEW CONDENSER FOR CAMPHOR DISTILLATION

BY B. S. VARMA

Forest Research Institute, Dehra Dun

It has already been reported that *Ocimum kilimandscharicum*, Guerke is a new and effective source of camphor in India[1]. The plant is being raised in several localities on a large scale for the production of camphor.

In the distillation of *Ocimum* leaves, the distillate, unlike other essential oils, consists of two phases, viz., a liquid phase containing condensed water and camphor oil and a solid phase consisting of congealed camphor deposited on the walls of the condenser. In the ordinary types of condenser the congealing camphor very rapidly chokes up the narrow passage, obstructing the flow-out of the liquid distillate. Further considerable difficulty is experienced in effecting the removal of the congealed camphor by scraping. A new type of condenser has now been evolved, in which the above drawbacks are eliminated. It is based on the idea of the Davis Double Surface Condenser in which the two water-jackets are now made detachable. Its description and fabrication are given below :

DESCRIPTION

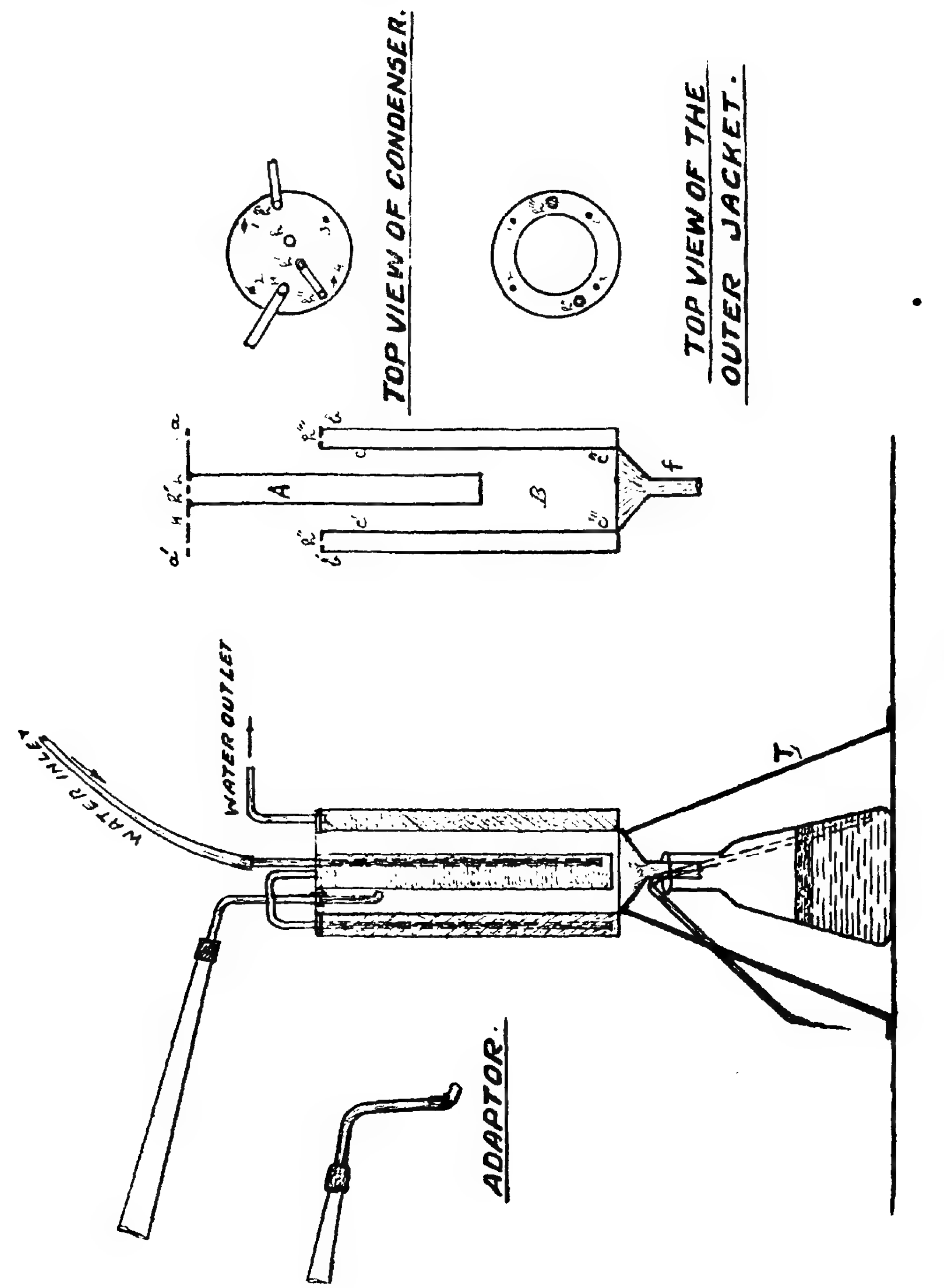
The condenser can be made from any metal sheet like zinc or copper, but in its cheapest form it can be prepared from G.I. sheetings. It is essentially a vertical cylinder enclosed within two cylindrical jackets, outer and inner, one hanging in the other as shown in the Fig. 1.

The inner jacket A, is a round vertical and hollow cylinder 22 inches long and 3 inches in diameter, closed at the bottom. On the top it is soldered in to the centre of a 10 inches diameter disc aa′, having two holes h and h′, $\frac{3}{4}$ inch each leading into the jacket. The outer jacket B is a double-walled cylindrical vessel, 24 inches long, with outer wall, bb′ of 10 inches in diameter and inner wall, cc′ 7 inches in diameter. The two walls are closed both on the top and the bottom ; the top has 2 holes, h″ and h″ ′, $\frac{3}{4}$ inch wide each. The cylinder formed by the inner wall cc′ c″ and C″ ′ is open at the top but sealed with a funnel shaped bottom, f, below. A is hung in position over B when the disc aa′ rests on bb′ and is screwed with 4 provided screw-bolts and fly-nuts, 1, 2, 3 and 4, having a gasket of asbestos or soft cotton rope in between. There are two more holes in the disc to correspond to the holes h″ and h″ ′. There is also another hole H of 1 inch wide in the disc opening in the annular space between A and B which is meant to receive the vapour-loaded steam from the still for condensation.

The circulation of water in A and B has been shown in the diagram. Through hole h a narrow glass or metallic tube is pushed tight into the jacket A, leading up to its bottom. This tube is connected to a water tap on the top. Through the hole, h″ in the outer jacket B, is pushed a similar tube leading to its bottom. Above the disc this tube is joined by a glass or copper bend to the hole h′ in A. The hole h″ ′ is connected with an exit tube. Water entres A through the tube in the hole h, fills it up and comes out through h′, enters B through h″, fills it up and gets out through h″ ′. A metallic adaptor is held tight with a bored cork in the hole H and is connected to the swan-neck of a still. The whole condenser rests on an iron triped T.

The vapours from the still enter through the adaptor into the annular space between A and B, when camphor congeals on the cold surfaces, while the condensed water and oil flow down into the funnel, and through the funnel into a receiver placed below. Oil and water

FIG. 1.



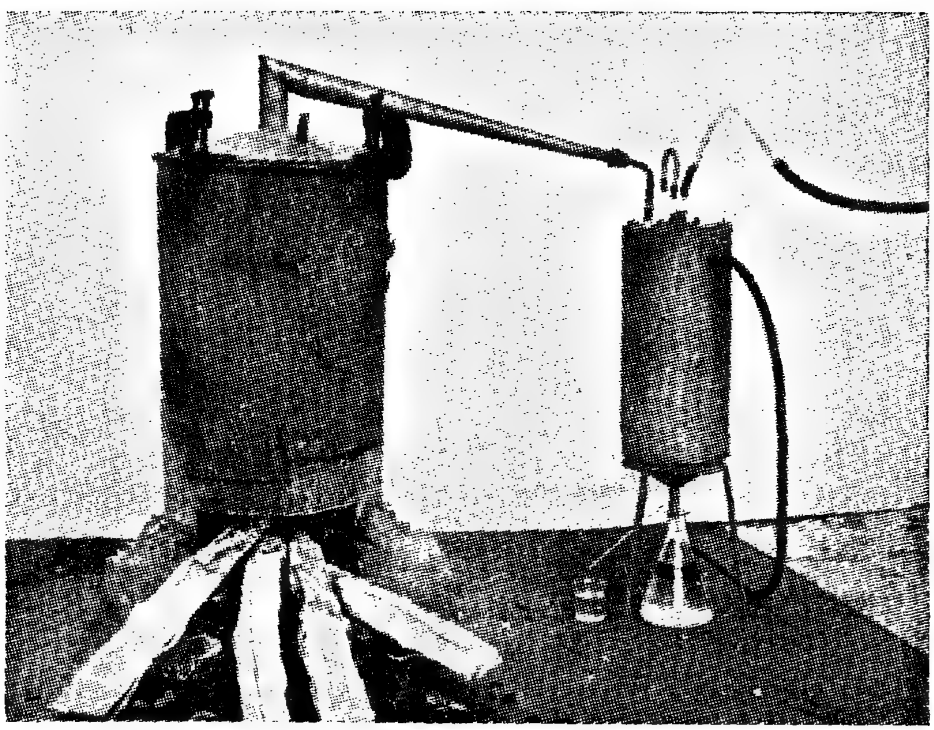
F.R.I. CAMPHOR CONDENSER.

separate in the receiver into two layers, oil remaining floating. A bent glass tube is put in the receiver as shown in the figure, which is kept tilted in such a position that its outer end remains about half-way above the height of the receiver. When the receiver is half full with the distillate, water is sucked out from the tube and left, when the tube begins to act as a syphon. As the receiver gets more and more of the distillate, the water from the lower layer gets on dropping out by the tube. Camphor is scraped off after setting apart jackets A and B and filtered through a filter bag or a centrifuge. The oil after separation from the water is congealed in cold or by keeping overnight, when it throws down some more of the dissolved camphor which is also similarly filtered and dried.

Still—A still can be fabricated of any shape and size from any metal, but it can easily be improvised by converting an ordinary spirit or petrol barrel and getting a suitable swan-neck made for it.

Fig. 2 below shows the new condenser in use with such a still, which can take charge of 40 lbs. of leaves at a time. It is always convenient to open the condenser after 5 to 6 charges have been distilled through. Usually it takes about 2 hours for each charge to be exhausted.

FIG. 2



A new condenser for camphor distillation.

The efficiency of the new condenser has been tested by comparing the yields of the total distillate with that obtained in laboratory from the same samples. Comparative data of the recoveries obtained are stated below :—

Sample No.	Total Distillates		Efficiency %
	By New Condenser %	Lab. estimation %	
I	2·11	2·12	99·5
II	2·80	2·81	99·7
III	3·95	3·95	100
IV	3·40	3·40	100

For large scale distillation, using steam, generated in a separate boiler, and a big still, a battery of 4 or more such condensers can be used.

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THE RAJPUTANA DESERT

A SCHEME FOR ITS IMMOBILIZATION

BY M. D. CHATURVEDI, I.F.S.
Inspector-General of Forests

SUMMARY

The diversion of the drainage of the Gangetic Plain from the Arabian Sea towards the Bay of Bengal brought about by earth movements which folded up the Siwaliks coupled with the sands left in the wake of the recession of what was during geological times an extension of the Gulf of Cutch have given rise to the vast stretch of the inhospitable and arid tract known as the Rajputana desert, covering an area of about 80,000 square miles. In the saline alluvial marshes of the Runn of Cutch, to the south-west of the desert, we have an illustration par excellence of the desert in the making by the desertion of the sea ; the process having been accelerated by the deposition of the silt brought down by the Hakra, now extinct, and the Luni. Strong winds, which develop in this region during the summer and gather great momentum during the monsoon months, transport, vast quantities of salt and sand to the Rajputana desert whipping it up into terrific dust storms, the fury of which is felt throughout the north-western India. The desert has spread through the ages causing the 'westering' of the Indus and the 'northering' of the Sutlej, meeting an obstruction of sorts only along its eastern confines in the Aravallis and their extension up to the Delhi Ridge.

2. The scheme to immobilize the desert envisages in its briefest outline the following projects :—

I. A Desert Research Station at Jodhpur to study the silviculture of indigenous vegetation, its succession and propagation, suitability of exotics such as mesquite, study of soils, hydrological conditions, and wind velocity ; and

II. the Station at Jodhpur undertaking extension work consisting of :
- (*a*) distribution of seeds and plants,
- (*b*) establishment of oases as nuclei for the spread of vegetation around Police Constabulary Posts on the border, railway stations, schools, etc.,
- (*c*) creating a 5-mile wide belt 400 miles long 5 miles inside and parallel to the border,
- (*d*) establishing shelter belts along selected roads, railway lines running transversely to the direction of the wind,
- (*e*) improved agricultural practices and animal husbandry, rotational grazing, etc. and
- (*f*) establishment of six fuel and fodder reserves of not less than a thousand acres each to demonstrate rotational lopping and grazing.

Geological evidence has been adduced in support of the hypothesis that before the gap between the Rajmahal and Garo hills came into being, the Gangetic Plain drained itself through the Indus into the Arabian Sea. Subsequent earth movements, which folded up the

Siwalik bed, led to the subsidence of the Gangetic Plain eastwards, culminating in the diversion of its drainage towards the Bay of Bengal. Lifted several hundred feet above its original level, the old channel, which drained the Siwalik Rivers in geological times, was left high and dry and became in course of time the core of the Thar desert. The desert extends to-day over a width of about 200 miles westwards from the ancient Aravallis towards the Indus. Abutting the Great Runn of Cutch in the south, it gradually spreads itself out until it reaches the Sutlej, traversing a distance of about 400 miles. The Thar desert occupies an area of 80,000 square miles menacing the entire north-western region of the country.

2. The drainage of the Indus Plain has been in a state of flux through the ages. The Indus, at the time of the invasion of Alexander the Great, emptied itself in the Great Runn of Cutch and has since shifted its course westwards by about a hundred miles. Mohenjo-daro (the ancient city of *c.* 3,000 B.C. recently excavated) constitutes the fulcrum of the Indus pendulum swinging from east to west, its existing position having been buttressed by the Kirthar range on its right bank. The Sutlej which takes its rise in the Mansrowar lake, to the south of Kailash, has also during historic times given up its old Hakra (Ghaggar) course, once said to be navigable from Delhi to Multan. It now joins the Beas above Firozepur, instead of at Bhawalpur about 150 miles down the river. Similarly, the confluence of the Ravi and the Chenab rivers at Multan at the time of Tamerlane's invasion (1398) has shifted up by about 30 miles (Ahmedpur). Evidence can be adduced that the Punjab rivers although held in check by one another's high banks have changed their courses within historic times. Of particular interest is the Sarswati, referred to in the ancient Aryan epics as being one of the rivers which drained the Sirhind gap between the Jumna and the Sutlej and joined the former to lend its name to the confluence of the Jumna and the Ganges at Allahabad as the Triveni (3 rivers). The Sarswati has completely disappeared giving rise to considerable speculation regarding its former position. It has been suggested that the Sarswati in the days gone by joined the Sutlej when it occupied the Ghaggar (Hakra) course.

3. The low-lying Great Runn (marsh) of Cutch (*c.* 8,000 square miles) bridges the mainland with what was once a group of 7 islets in the estuary of the lost river, the Hakra – probably the lower arm of the Siwalik drainage. These islets enjoyed a distinct entity as recently as the Invasion of Alexander the Great (325 B.C.). What was not very long ago an inlet of the Arabian Sea, is to-day a desolate stretch of saline alluvium and wind-borne sand, supporting neither vegetation nor life. Further south, the Little Runn of Cutch, a continuation of the Gulf of Cutch, exhibits an analogous formation with the Kathiawar overlying lava soils blowing on to it. The desiccation of the entire tract is brought about by strong winds which develop during the summer. Gathering great momentum during the early monsoon months, they transport vast quantities of salt and sand up the Luni valley whipping the desert into terrific dust storms, the fury of which is felt throughout the Punjab and the Sirhind. As a matter of fact the saline nature of the Rajputana desert has been ascribed, by some authorities, to this source. Peculiar only to this region, the Runn formation has been caused by the dissidence of the sea which left in its trail marshy and brackish swamps which came to be filled up with saline riverain and wind-borne sands and soil, exhibiting here and there leucodermic patches of pure white salt. In the Runns to-day we have the desert in the making by the desertion of the sea, furnishing a clue to the formation of at least the southern half of the Thar desert which within historic (*Vedic*) times was known to be a marshy tract.

4. The topography of the desert is occasionally relieved by rocky projections of the *Purana* series suggesting 'deep-seated' affinity with the Deccan. These hillocks shelter a certain amount of xerophytic vegetaion. The desert sands are composed of wind-worn,

well rounded quartz grains admixed with those derived from felspar, hornblende and limestone. The coarser and the angular variety of sand betrays its foreign origin, viz., the head of the Arabian Sea. Whether the aridity of this region, as evinced by its low rainfall (5 inches), the diurnal variation in temperature often reaching 100°F. and even greater seasonal variation in heat and cold, caused the desert or the desert caused the aridity, is a matter for idle speculation of the egg-and-hen pattern. The fact remains that the spread of the desert is without doubt accentuated by its extreme aridity, powerful insolation, and strong winds.

5. The Aravallis and what looks like its absentminded continuation up to the Delhi Ridge (*Purana* series) have constituted some sort of a rampart against the eastward extension of the desert. The defences on west were, however, far more vulnerable. The Hakra – the old distributary of the Indus and probably fed by the Sutlej in its upper reaches – could not withstand the incessant encroachment of the desert, and sought a more westerly course as recently as 1790. This 'westering' of the Indus is responsible for the abandonment of the old delta, which in fact the Runn represents, and considerable extension of the desert westwards. In the north, the Sutlej has by no means remained unaffected by the onslaught of the desert, as its abandonment of the old 'Ghaggar' course, now dry, and subsequent confluence with the Beas suggests. While the desert has brought about the 'westering' of the Indus and the 'northering' of the Sutlej, its march eastwards has been brought about in the main by the wind action, as aeolian deposits of loess and sand in the tract across the Aravallis suggest. Thus, it will be seen that not only do we have a large desert blocking the right lung of India through which are sucked in sand and salt instead of rain sweet and soft, but what is very much worse, this desert is on the march.

6. To arrest the onward march of the desert sands, which threaten to engulf the fertile alluvium of the Indo-Gengetic Plain, is a herculean task requiring skill, patience, labour, and above all large funds. It is necessary to strike here a note of warning that projects of this nature seldom yield immediate and direct dividends. The success of such protective schemes is to be measured not by what they produce, but by what they protect.

7. The Ministry of Food and Agriculture had recently appointed an *ad hoc* Committee of technical experts to advise them on the measures to be taken for the immobilization of the Rajputana desert. After a detailed study of the problem in the desert zone, the Committee has unanimously made a number of recommendations, the more important of which are detailed below :—

I. a Desert Afforestation Research Station under the aegis of the Forest Research Institute, Dehra Dun should be set up at Jodhpur to study, *inter alia*—

(*a*) the silviculture of indigenous species ;

(*b*) the possibilities of introducing exotic desert species ; and

(*c*) the edaphic factors, hydrological conditions, rainfall and wind velocities.

The Station will maintain a large seed store for distribution, free of cost, of seeds of various desert species that are comparatively immune from browsing ;

II. demonstration of desert control methods by

(*a*) organizing the growing of plants at police stations, railway stations, tehsils and schools ;

(*b*) creation of a belt approximately 400 miles long and 5 miles wide in about 10 years parallel to the Pakistan boundary, and located about 5 miles inwards of the western border of Rajasthan ;

(*c*) establishing shelter-belts along selected roads and railway lines running transversely to the direction of winds ;

(*d*) a nursery at Jodhpur for distribution of plants ;

(*e*) wide publicity indicating

(i) harmful effects of cultivation on dunes ;

(ii) advantages of creating windbreaks round each field ;

(iii) correct agricultural practices ;

(iv) improved methods of lopping ;

(*f*) best method of afforestation in six blocks of not less than a thousand acres each distributed on different types of sand ;

III. to establish a technical co-operation assistance plan of the Ford Foundation Trust in the region to demonstrate correct land use ; and

IV. to request the Rajasthan Government

(i) to increase the forest area to 50 per cent ;

(ii) to adopt improved methods of agriculture and creation of wind-belts round cultivators' fields ;

(iii) to create forest belts along railway lines and roads ;

(iv) establishment of seed stores at suitable centre of the Rajasthan Forest Departments ; and

(v) co-ordination with similar work that is being undertaken by the Central Water and Power Commission.

8. It may be pointed out here that projects of this nature, like the construction of a dam, do not lend themselves to interruption or to fractionalization. A project once taken in hand must be completed in time, if money and energy are not to be lost in sands. While it is possible to postpone one or more of the projects outlined above, but a division once constituted cannot be wound up until the project it provides for has been completed. Thus, no useful purpose will be served by leaving the Luni Belt incomplete or tackling the fixation of a few sand dunes in a locality. Of course, the speed of an individual project can be slowed down to meet financial exigencies.

9. The value of a scheme like the fixation of desert sands in the general economy of the country is easier imagined than described. Incontrovertible evidence has been adduced during recent years demonstrating the fact that the desert is on the march. Its progress is slow but sure, and is all the more dangerous, because it is insidious. Money spent on this project should be considered as a premium for insuring the Indo-Gangetic Plain against an otherwise inexorable fate from which there seems no escape.

It is understood that the Government of India has since accepted the recommendation of the *ad hoc* Committee relating to the creation of a "Desert Afforestation Research Station" under the ægis of the Forest Research Institute, Dehra Dun and has sanctioned the necessary staff for the same as well as the funds. Further, American aid to the tune of twenty-five thousand dollars, has also been secured under the Technical Co-operation Assistance Programme, for this scheme.

[ED.].

RUSSEL EFFECT IN INDIAN TIMBER WOODS

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(*Date of communication 12th June, 1952*)

SUMMARY

The present paper deals with the details and results of an investigation made for the first time on the photographic activity of 40 representative specimens of Indian timber woods. Attempt is also made for the first time to measure the activity and to express it in a quantitative manner. The activity is found to be generally different for the different species of wood, though certain woods were found to exhibit the same amount of activity. Exposure to sunlight and ultra-violet light increases the activity. Extraction of the specimen with a mixture of benzene-alcohol with a view to eliminating the resinous bodies, results in an appreciable diminution in the activity of the specimen. The Russel effect exhibited by the different woods are expressed relative to teak taken as standard.

The author's thanks are due to the Forest Utilization Officer, Government of Madras, through whose courtesy the specimens were procured. His thanks are also due to the authorities of the Pachaiyappa's College, Madras, for giving him all facilities to carry on the present investigation.

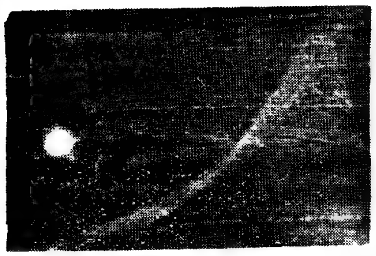
INTRODUCTION

An interesting property of Indian timber woods which has not so far been investigated in this country, is their capacity to act in total darkness, on photographic emulsions. For the action to be observed it is only necessary to place the specimen of wood in contact with, or extremely near to, the sensitized surface of a photographic plate in total darkness and allow it to stand over, undisturbed, for a few hours ; whereupon the plate after development in the usual way, will be found to have received on it, an image of the specimen. In the case of certain woods the pictures obtained are remarkably clear and sharp, and extremely faithful in regard to the reproduction of the grain structure and surface markings of the original specimen. This property of wood, of acting on photographic emulsions and registering an image thereon in absolute darkness, in complete defiance of the fundamental principles of photography, was first observed by W. J. Russel[1] of England, and is sometimes referred to in photographic literature as the Russel effect[2].

A preliminary investigation of this phenomenon was carried out in England by Russel, who conducted experiments on a number of European timbers and studied their activity on a photographic plate. An attempt was also made by him to classify the different woods according to their photographic activity.

A similiar investigation in regard to Indian timbers seemed highly desirable. The author is not aware of any work having been attempted so far in this direction, and the proposed study, therefore, opens up unlimited possibilities for research.

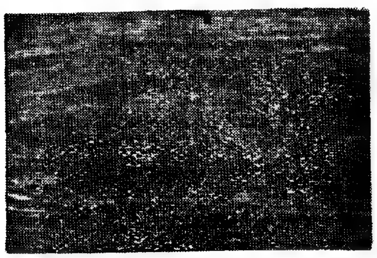
It must also be mentioned here that Russel's investigations were purely qualitative in as much as no attempt had been made by him to study the effect precisely in the case of each of the different species of wood and to express it in a quantitative form. The possibility of making use of the modern experimental techniques to study the phenomenon quantitatively was another aspect of the problem which suggested itself to the author, and contributed greatly to his taking up this problem for research in the laboratories of this college.



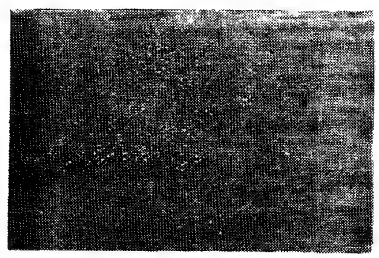
Dalbergia latifolia
(plate 1)

Butea frondosa
(plate 2)

Morinda citrifolia
(plate 3)

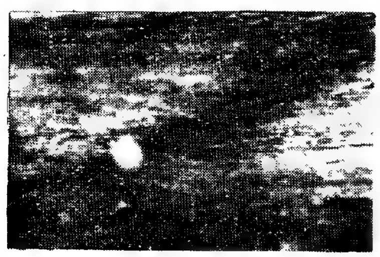


Myristica attenuata
(plate 4)

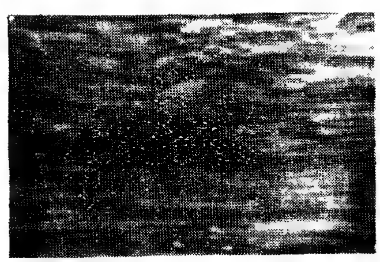


Dichopsis elliptica
(plate 5)

Poeciloneuron indicum
(plate 6)



Phyllanthus emblica
(plate 7)

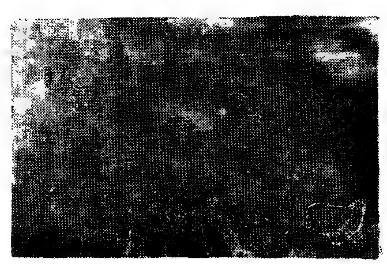


Acrocarpus fraxini-
folius (plate 8)

Cullenia excelsa
(plate 9)

Erythrina indica
(plate 10)

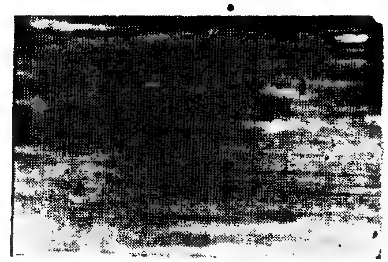
Artocarpus integrifolia
(plate 11)



Anogeissus latifolia
(plate 12)

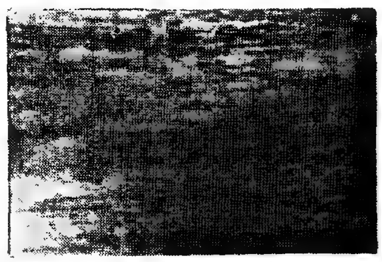
Mesua ferrea
(plate 13)

Bridelia retusa
(plate 14)

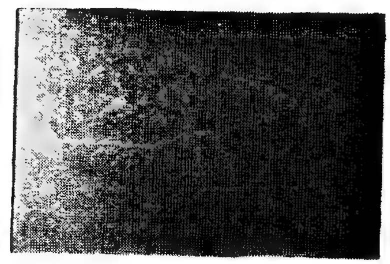


Holigarna arnottiana
(plate 15)

Calophyllum elatum
(plate 16)

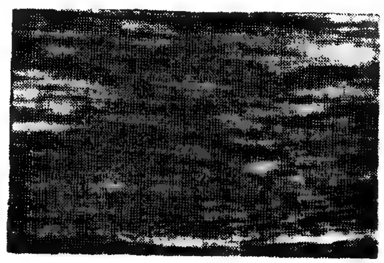


Acacia arabica
(plate 17)



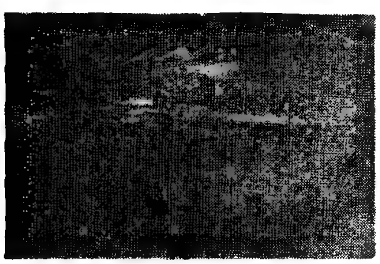
Ficus glomerata
(plate 18)

Terminalia belerica
(plate 19)

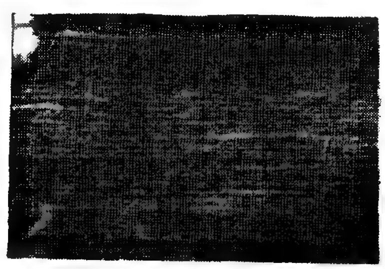


Cassia fistula
(plate 20)

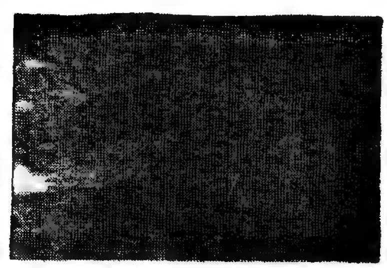
Grewia tiliaefolia
(plate 21)



Wrightia tinctoria
(plate 22)



Ficus hispida
(plate 23)



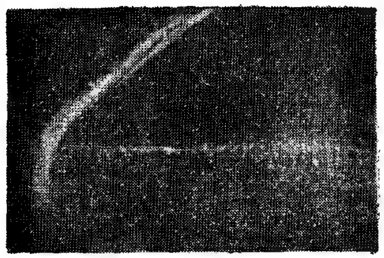
Albizzia procera
(plate 24)

Vateria indica
(plate 25)

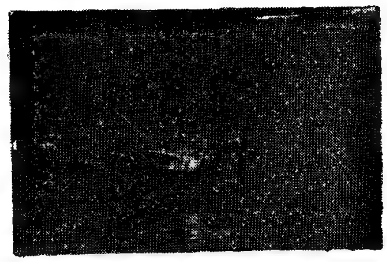
Machilus macrantha
(plate 26)

Dalbergia paniculata
(plate 27)

Pterocarpus marsupium
(plate 28)

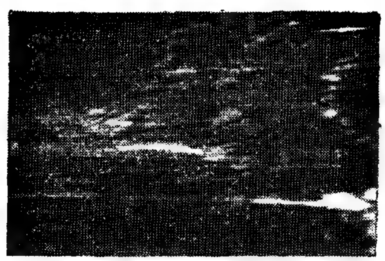


Bischofia javanica
(plate 29)

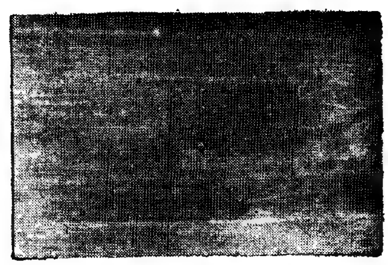


Mangifera indica
(plate 30)

Mallotus philippinensis
(plate 31)

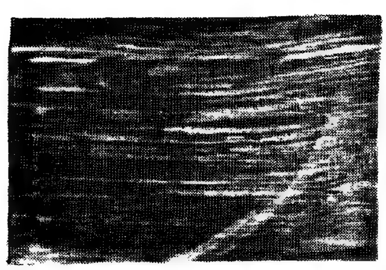


Acacia ferruginea
(plate 32)



Tectona grandis
(plate 33)

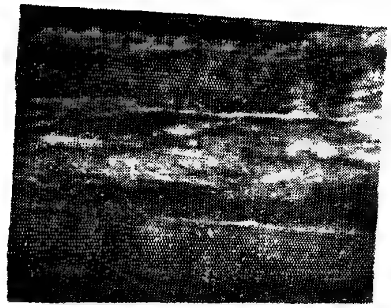
Terminalia paniculata
(plate 34)



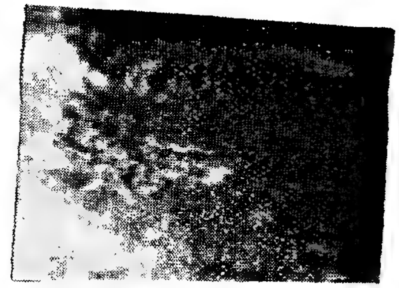
Lagerstroemia lanceolata
(plate 35)

Pongamia glabra
(plate 36)

Zizyphus jujuba
(plate 37)

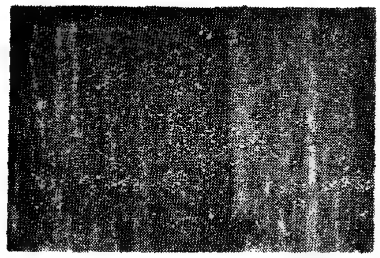


Strychnos Nux-vomica
(plate 38)

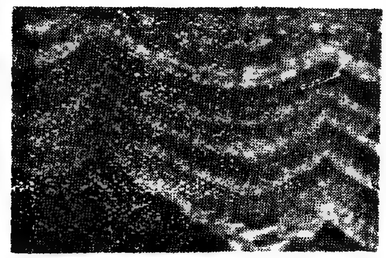


Melia azadirachta
(plate 39)

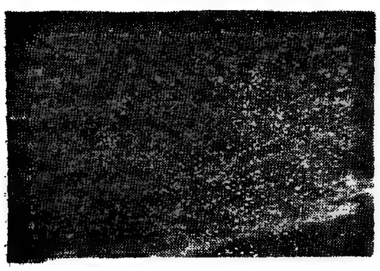
Kigelia pinnata
(plate 40)



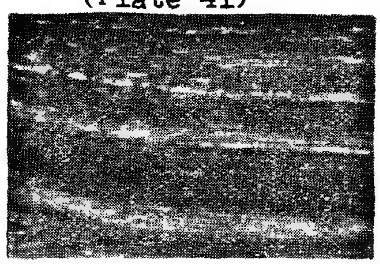
Tectona grandis
(age 66 years)
(Plate 41)



Tectona grandis
(age 65 years)
(plate 42)

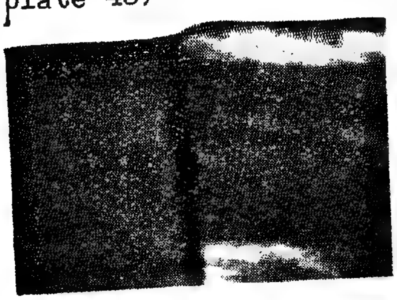


Tectona grandis
(age 27 years)
(plate 43)

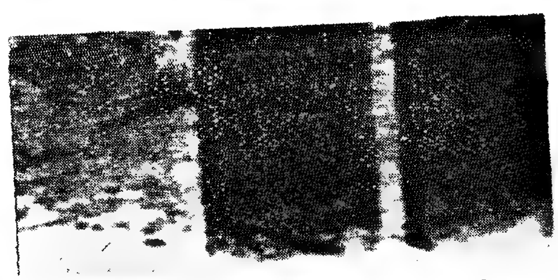


Tectona grandis
(age 21 years)
(plate 44)

Unexposed   Exposed to sun light
(plate 45)



Unexposed   Exposed to ultra-violet light
(plate 46)



Exposed under
Blue filter   Green filter   Red filter
(plate 47)

The results of the preliminary investigations conducted by the author were set out in two notes which appeared Current Science[3, 4]. The present paper is an amplification of the above and deals more fully with the nature and scope of the problem, and the experimental arrangement and technique employed.

EXPERIMENTAL DETAILS

For the purpose of the present investigation 40 representative specimens of Indian timbers were selected. The specimens were obtained from the Nilambur Forests, Malabar. The botanical names of the specimens are :—

(1) *Dalbergia latifolia* (2) *Butea frondosa* (3) *Morinda citrifolia* (4) *Myristica attenuata* (5) *Dichopsis elliptica* (6) *Pœciloneuron indicum* (7) *Phyllanthus emblica* (8) *Acrocarpus fraxinifolius* (9) *Cullenia excelsa* (10) *Erythrina indica* (11) *Artocarpus integrifolia* (12) *Anogeissus latifolia* (13) *Mesua ferrea* (14) *Bridelia retusa* (15) *Holigarna arnottiana* (16) *Calophyllum elatum* (17) *Acacia arabica* (18) *Ficus glomerata* (19) *Terminalia belerica* (20) *Cassia fistula* (21) *Grewia tiliæfolia* (22) *Wrightia tinctoria* (23) *Ficus hispida* (24) *Albizzia procera* (25) *Vateria indica* (26) *Machilus macrantha* (27) *Dalbergia paniculata* (28) *Pterocarpus marsupium* (29) *Bischofia javanica* (30) *Mangifera indica* (31) *Mallotus philippinensis* (32) *Acacia ferruginea* (33) *Tectona grandis* (34) *Terminalia paniculata* (35) *Lagerstrœmia lanceolata* (36) *Pongamia glabra* (37) *Zizyphus jujuba* (38) *Strychnos nux-vomica* (39) *Melia azadirachta* and (40) *Kigelia pinnata*.

The specimens under investigation were in the form of rectangular blocks ($1\frac{3}{4}'' \times 1'' \times \frac{1}{2}''$) their broad faces being planed and rendered perfectly smooth to ensure proper contact with the sensitive side of the photographic plate. They were then exposed to the sun and irradiated by bright sunlight for 10 minutes. As will be seen later such exposure increases the activity of the specimen.

The wood under experiment was then placed in contact with the sensitized surface of a photographic plate in a dark room and secured in position by means of elastic rubber bands. The wood and the plate were thereafter wrapped completely in thick black paper and placed in a card board box. The box itself was placed in a bigger light tight box and the latter was carefully wrapped in black cloth. Every care was thus taken to exclude completely the possibility of any stray light leaking in and vitiating the results by extraneous fogging. The arrangement was allowed to stand over in the dark room attached to our laboratories.

As was observed by the author in his earlier publications on the subject, extremely long exposures had to be given to obtain a perceptible effect. An exposure of 48 hours was found suitable. The plates were thereafter taken out and processed in the usual way using a standard developer (ID–35)[5] and fixer (G–303)[6]. Care was taken to see that the temperature and time of development remained the same in every case.

The photographic plates used for this experiment were the Special Rapid Plates manufactured by Ilford Limited, London. The plate had a speed of 20° Scheiner and a range of spectral sensitivity from 2300 to 5200 A. The temperature and time of development were 75°F. and 3 minutes respectively.

The density of the Russel images was measured using a photo-electric cell. A 10 volt 7·5 amp. A.S.S.C. photo cell exciter lamp was used as the illuminant. The output of the photo cell was thermionically amplified using a valve amplifier circuit. The circuit was designed and built by Messers Pratibha Electronics, Madras, to whose managing proprietor Shri K. Sudhakaran, the author's grateful thanks are due. The galvanometer reading in

every case was carefully recorded and the transmittancy, absorption and density of the image calculated. If I_o and I represent the intensity of the light transmitted by the clear portion of the photographic plate and the silver image respectively, I/I_o measures the transmittancy (T) and 1–T the absorption and log (I_o/I) the optical density[7].

The results obtained are recorded in Table I. Table II gives the activity of the woods under investigation relative to the well-known Indian teak (*Tectona grandis*) taken as a standard.

It might be mentioned here that as the specimens were all derived from the Sapwood (outer portions) of the respective timber species, a comparative study of the activity of sapwood and heartwood of any one species of wood has been reserved for a separate study. Experiments in this direction are already in progress in the laboratories of this college and another paper will follow as soon as conclusive results are obtained.

The action of sunlight on the photographic activity of wood was also investigated. The piece of wood was half covered with thick black paper, and exposed to sunlight for 10 minutes. It was then put in the usual way in contact with a photographic plate. The plate when developed was found to give a darker image in the regions where light fell and only a faint one in the unexposed region. Sunlight, therefore, has the distinct effect of increasing the photographic activity of wood. In this respect Indian timbers behave in the same way as their European counterparts.

The relative influence of the different parts of the spectrum of sunlight on the photographic activity of the specimen was studied. Red, green and blue glass filters were placed on the specimen which was then exposed to sunlight. It was found that the activity was the least in the region covered by the red filter and most in that of the blue filter. The conclusion, therefore, is that it is the blue region of the spectrum that is mostly responsible for the enhanced activity of the wood.

The effect of ultra-violet radiation on the activity of wood was next investigated. The specimen was half covered with several folds of thick black paper and exposed to the radiation from an ultra-violet lamp for 10 minutes. The lamp was then switched off, the paper covering removed and the wood placed in contact with the photographic plate in the usual way. An exposure of 48 hours was given. The plate when developed gave a picture which showed a marked difference between the exposed and the unexposed regions, the former exhibiting distinctly greater activity than the latter. Exposure to ultra-violet rays, therefore, increases the photographic activity of the wood. The effect of ultra-violet radiations does not seem to have been investigated by Russel and is now done for the first time.

According to Russel the resinous bodies present in the wood produce hydrogen peroxide in the process of oxidation and the latter is responsible for the photographic activity. To test the correctness or otherwise of this explanation a simple experiment was conducted.

If the action is really due to the resinous bodies present in the wood, elimination of such bodies must undoubtedly arrest the activity. One of the specimens was now placed in a mixture of benzene and alcohol and allowed to stand in it for over three days. The resinous bodies being soluble in the mixture were extracted by the solvent from the wood. The specimen was taken out, and after drying, was put in contact with the photographic plate in the usual way. On developing the plate it was found that the impression obtained was considerably faint, the wood having lost an appreciable amount of its activity. It seems true that the resinous bodies present in the wood do play a considerable part in exerting the observed action on photographic emulsions, though of course further experiments are necessary to understand the exact mechanism of the action and conclude whether the hydrogen peroxide

theory put forward by Russel is correct or not. Experiments in this direction are now in progress in our laboratories.—

DISCUSSION OF RESULTS

From a perusal of Tables I and II, it is clear that all the woods under investigation exhibit Russel effect to a greater or lesser degree. The most active among the woods so far investigated is *Calophyllum elatum* which registered an image whose density was found to be nearly three times that of teak. Other woods which exhibited pronounced photographic activity were *Pœciloneuron indicum, Grewia tiliæfolia, Terminalia paniculata* and *Melia azadirachta*, all of which were found to be more than twice as active as teak. The action was found to be the same in the case of certain woods. In this category come (1) *Grewia tiliæfolia* and *Terminalia paniculata* (2) *Cullenia excelsa* and *Acacia arabica* (3) *Phyllanthus emblica* and *Pongamia glabra* (4) *Erythrina indica, Holigarna arnottiana* and *Butea frondosa* (5) *Cassia fistula, Machilus macrantha* and *Zizyphus jujuba* (6) *Dalbergia latifolia, Dichopsis elliptica, Ficus glomerata* and *Ficus hispida* (7) *Myristica attenuata, Terminalia belerica* and *Wrightia tinctoria* (8) *Artocarpus integrifolia* and *Anogeissus latifolia* and (9) *Vateria indica* and *Pterocarpus marsupium*. The well-known Jackwood (*Artocarpus integrifolia*) and axle-wood (*Anogeissus latifolia*) approximately equalled teak in their photographic activity. Mango-wood (*Mangifera indica*) recorded an image whose transmittancy and absorption were exactly equal. The popular Rose-wood (*Dalbergia latifolia*) was found to be slightly more active than teakwood.

The two members of the *Ficus* family, *Ficus glomerata* and *Ficus hispida* exhibited the same measure of activity. The activity, however, was not the same in the case of the two woods of the *Dalbergia* and *Acacia* families. Thus the activity of *Dalbergia latifolia* was found to be a little over twice the activity of *Dalbergia paniculata*. The same proportion more or less governed the activities exhibited by *Terminalia paniculata* and *Terminalia belerica* and *Acacia arabica* and *Acacia ferruginea*. On the data available it seems, therefore, difficult to attempt any correlation between the photographic activity of the wood and the family to which it belongs.

The weakest of the woods from the standpoint of photographic activity is *Dalbergia paniculata*. As will be seen from the tables its activity is only a little over half that of teak-wood. The picture registered by it on the photographic plate was extremely faint and indistinct. So were *Mangifera indica, Mallotus philippinensis, Bischofia javanica,* all of which left only extremely feeble impressions on the photographic plate. That is why the Russel pictures registered by them are extremely faint and indistinct. (Vide Plates 29, 30 and 31). All, the same they are all photographically active and the images recorded by them show an absorption of nearly 50 per cent.

Plates 41, 42, 43 and 44 represent the 'Russel images' recorded by *Tectona grandis* derived from trees of ages, 66, 65, 27 and 21 years, that is from trees planted in the years 1886, 1887, 1925 and 1931 respectively. These were also obtained from Nilambur Teakwood plantations through the courtesy of the Government of Madras.

Plate 45 represents the picture obtained in the case of a wood, half of which was activated by sunlight. The increased activity exhibited by the wood can be clearly seen. Plate 46 represent the picture registered by the same wood, this time under exposure to ultra-violet radiation, Plate 47 illustrates the effect of exposure of wood to the red, green and blue regions of the solar radiation. The activity is found to be greater in the region covered by the blue filter than in that exposed through the red filter.

TABLE I

Serial No.	Name of Wood	Transmittancy %	Absorption %	Density
1	*Dalbergia latifolia*	32·9	67·1	0·483
2	*Butea frondosa*	28·9	71·1	0·508
3	*Morinda citrifolia*	40·8	59·1	0·390
4	*Myristica attenuata*	35·5	64·5	0·450
5	*Dichopsis elliptica*	32·9	67·1	0·483
6	*Pœciloneuron indicum*	7·8	92·1	0·985
7	*Phyllanthus emblica*	25·0	75·0	0·591
8	*Acrocarpus fraxinifolius*	28·3	71·7	0·523
9	*Cullenia excelsa*	23·7	76·3	0·626
10	*Erythina indica*	28·9	71·1	0·508
11	*Artocarpus integrifolia*	36·8	63·2	0·434
12	*Anogeissus latifolia*	36·8	63·2	0·434
13	*Mesua ferrea*	27·4	72·6	0·560
14	*Bridelia retusa*	26·3	73·7	0·580
15	*Holigarna arnotiana*	28·9	71·1	0·508
16	*Calophyllum elatum*	6·6	93·4	1·172
17	*Acacia arabica*	23·7	76·3	0·626
18	*Ficus glomerata*	32·9	67·1	0·483
19	*Terminalia belerica*	35·5	64·5	0·450
20	*Cassia fistula*	31·6	68·4	0·501
21	*Grewia tiliœfolia*	10·5	89·5	0·978
22	*Wrightia tinctoria*	35·5	64·5	0·450
23	*Ficus hispida*	32·9	67·1	0·483
24	*Albizzia procera*	28·0	72·0	0·538
25	*Vateria indica*	46·1	53·9	0·337
26	*Machilus macrantha*	31·6	68·4	0·501
27	*Dalbergia paniculata*	55·3	44·7	0·232
28	*Pterocarpus marsupium*	46·1	53·9	0·337
29	*Bischofia javanica*	52·6	47·4	0·279
30	*Mangifera indica*	50·0	50·0	0·301
31	*Mallotus philippinensis*	51·3	48·7	0·290

(contd.)

TABLE I—*concld.*

Serial No.	Name of Wood	Transmittancy %	Absorption %	Density
32	*Acacia fevruginea*	47·4	52·6	0·325
33	*Tectona grandis*	39·5	60·5	0·421
34	*Terminalia paniculata*	10·5	89·5	0·978
35	*Lagerstrœmia lanceolata*	33·9	66·1	0·477
36	*Pongamia glabra*	25·0	75·0	0·591
37	*Zizyphus jujuba*	31·6	68·4	0·501
38	*Strychnos nux-vomica*	17·1	82·9	0·767
39	*Melia azadirachta*	13·2	86·8	0·881
40	*Kigelia pinnata*	21·4	79·6	0·680

TABLE II

Serial No.	Name of the Wood	Activity relative to teak	Serial No.	Name of the Wood	Activity relative to teak
1	*Tectona grandis*	100	21	*Machilus macrantha*	119
2	*Calophyllum elatum*	278	22	*Zizyphus jujuba*	119
3	*Pœciloneuron indicum*	234	23	*Dalbergia latifolia*	115
4	*Grewia tilæfolia*	232	24	*Dichopsis elliptica*	115
5	*Terminalia paniculata*	232	25	*Ficus glomerata*	115
6	*Melia azadirachta*	209	26	*Ficus hispida*	115
7	*Strychnos-nux-vomica*	184	27	*Lagerstrœmia lanceolata* ..	113
8	*Kigelia pinnata*	162	28	*Myristica attenuata*	107
9	*Cullenia excelsa*	149	29	*Terminalia belerica*	107
10	*Acacia arabica*	149	30	*Wrightia tinctoria*	107
11	*Phyllanthus emblica*	140	31	*Artocarpus integrifolia*	103
12	*Pongamia glabra*	140	32	*Anogeissus latifolia*	103
13	*Bridelia retusa*	138	33	*Morinda citrifolia*	93
14	*Mesua ferrea*	133	34	*Vateria indica*	80
15	*Albizzia procera*	128	35	*Pterocarpus marsupium*	80
16	*Acrocarpus fraxinifolius* ..	124	36	*Acacia ferruginea*	77
17	*Erythrina indica*	121	37	*Mangifera indica*	72
18	*Holigarna arnottiana*	121	38	*Mallotus philippinensis*	69
19	*Butea frondosa*	121	39	*Bischofia javanica*	66
20	*Cassia fistula*	119	40	*Dalbergia paniculata*	55

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PROGRESSIVE DESICCATION OF NORTHERN INDIA IN HISTORICAL TIMES

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During his studies of the beautiful trees of ancient India the present author came across some interesting evidence, archaeological as well as literary which sheds light on the climate of northern India from C. 500 B.C. to C. 640 A.D. Most of this evidence is from Mathura region and is based on the study of numerous sculptures recovered from time to time from that district due to the efforts of pioneers like Mr. F. S. Growse, Pt. Radha Kishen, Dr. Fuhrer and others, and now housed in archaeological museums at Lucknow and Mathura. It shows that about 2,000 years ago the 'Brij' districts which to-day have a desert vegetation were covered with wet tropical forests containing evergreen trees of Indo-Malayan affinities which flourish at present in Assam, Bengal, Burma and west coast of India.

This evidence is in conformity with that obtained from the observations of Douglass and Ellsworth Huntington on the annual rings of Sequoia trees of South-western United States. This evidence shows that a very wet period prevailed from C. 100 B.C. to C. 100 A.D. and since then the curve of humidity has a downward trend on the whole with only brief interludes of wetness. Since then aridity has been on the increase though it cannot be said with certainty whether it is due to shifting of climatic zones or due to other causes. Writings of Herodotus show that Western Asia was very wet between 400–500 B.C. The presence of animals of the swamps like elephants and rhinoceros in Sind and the Western Punjab is proved from the seals recovered from Mohenjo-Daro and Harappa which date from C. 3250 B.C. to C. 2750 B.C. Sind and Western Punjab are practically deserts now, though the evidence from the presence of these denizens of swamps in these regions points towards considerable wetness if we bear the present distribution of elephant and rhinoceros in mind.

Mathura Sculptures of Woman and Tree Design.—In excavations carried out at the ancient site of *Kankali Tila*, about half a mile to the west of the present city of Mathura from 1888–91 A.D. Dr. Fuhrer discovered the remains of a Jaina monastery which proved to be a veritable mine of beautiful sculptures. Apart from graceful statues of Buddha and Jaina Tirathankaras, exquisitely carved bracket figures of Woman and Tree (*Salabhanjika*) design were discovered. The sculptors of these figures used spotted red sandstone, similar to that found in the quarries of Tantpore and Fatehpore Sikri in Agra district for carving these figures. Chronologically these 'Woman and Tree' bracket figures have been ascribed to the Kushana period, from 1 A.D. to 176 A.D., when Kanishka, Huvishka and Vasudeva ruled over Mathura from 78 A.D. to 176 A.D. The Kushan kings had their capital at Parsupura (Peshawar) and had a satrap at Mathura.

These bracket figures were described by Vincent Smith in 1901 in a valuable iconographic monograph, but he did not identify any of the trees. The comparatively undraped condition of these figures of women shocked his Victorian sense of sexual morality when over-clothing was regarded as a virtue and exposure of even legs and neck was regarded as a shameless impropriety. Describing these bracket figures, Vincent Smith writes, "These figures are indecently naked and could not be Buddhist. With the exception of one male figure in an obscene attitude, all these naked figures are female and seem to be intended for dancing girls. The costume, if such it may be called, consists solely of jewellery and an ornamental round the hips". However, we are more interested in the trees than the women, and these too were left unidentified by Smith who merely writes, "The trees under which the

women stand are in each case of a distinct kind. I cannot venture to identify the trees". It is for the first time that we find Asoka and Kadamba trees mentioned by name in the catalogue of the Mathura Museum compiled by Dr. Vogel in 1910. The remaining two trees have not been identified so far.

Yaksas or Dryads—Dr. Anand Coomarswamy is of opinion that these female figures represent Yaksas, or tree spirits which were worshipped as fertility goddesses, a demon cult which Buddhist faith had absorbed from pre-existing Animism. There is some doubt if all these figures of women represent dryads or fertility goddesses. We see women under beautiful tropical trees, bathing under a waterfall, feeding a parrot with fruit, drinking alcoholic liquor, or making love to men in branches of trees. Some of these can hardly be called symbols of fertility. It is also deserving of notice that the trees selected by the sculptors are beautiful jungle trees and they were selected on account of their overpowering beauty and common occurrence. The Kushan sculptors seem to have selected these trees and women from their environment with the object of conveying their daily experience. Even if these female figures represent fertility goddesses, the sculptors chose their models from among Kushan women of Mathura and trees from the surrounding forests.

A close examination of Mathura sculptures reveals that leaves and flowers of Asoka (*Saraca indica*) was a popular motif of their decorative designs along with flowers and leaves of the lotus. While the elephant, horse, lion and the antelope were their favourite animals, *Saraca indica* was their favourite tree. In the sculptures displayed in the Curzon Museum of Archæology at Mathura, and Provincial Museum, Lucknow we find numerous sculptures in which Asoka tree is associated with male and female figures. In the Bacchanalian groups discovered from villages Moholi and Palikhera we find the drooping branches of Asoka with its unmistakable lanceolate leaves and also an inflorescence. On a slab with the figures of a couple feeding a parrot we find the blossoming branch of Asoka on the lower panel. On another fragment we see a squirrel climbing an Asoka tree. On a railing pillar we see a woman standing under a flowering Asoka tree. We also see an exceptional figure which has been identified as Rishya Sringa son of Rishi Kashyapa under an Asoka tree, with a mystified expression of dawning sex-consciousness on his face.

Some of the Mathura sculptures displayed in the Provincial Museum, Lucknow are still more interesting. In one of these we find a beautiful woman with a happy face standing cross-legged on a crouching dwarf, fastening a lotus garland on her head. Behind her we see an exquisitely carved branch of *Saraca indica* with its characteristic lanceolate leaves and *Ixora*-like inflorescence (Fig. 1) which are so true to nature. In another we see a woman gathering Asoka flowers.

Apart from Asoka, we find three other trees depicted in these sculptures. In one of these we see a woman under a Kadamb tree (*Anthocephalus indicus*, Rich.) displaying sword dance and touching its ball-like flowers. The broad ovate leaves with conspicuously marked venation and globose inflorescences are prominent characters of *Anthocephalus indicus* which have been faithfully carved by the sculptor.

The third unidentified tree which we find appears to be Champak (*Michelia champaca*, Linn.) and forms a background to a beautiful female figure wearing a peculiar head-dress. The ovate lanceolate leaves tapering to a long point, segments of the perianth in three series, oblong sepals and the stalked gynophore with numerous carpels, are characters of *Michelia champaca*, Linn. a member of the family Magnoliaceae. The cone-like terminal structures appear to be the compound fruit of *Michelia champaca* rather than the flower.

The fourth tree with leaves like Asoka and comparatively smaller axillary flowers, which we find in a sculpture behind a woman treading over a dwarf resembles *Mesua ferrea*, Linn,

the well-known Nagsura tree of Eastern Bengal, Assam and Burma. Its linear-lanceolate acuminate drooping opposite leaves with short peduncles and axillary solitary flowers resemble those of *Mesua ferrea* rather than of any other Indian tree. *Mesua ferrea* with its strikingly beautiful leaves and highly fragrant flowers must have been as much popular in ancient India, as it is now in Eastern Bengal and Assam.

FIG. 1.

The accurate delineation of the foliage and flowers of these four trees, *Saraca indica*, Linn., *Mesua ferrea*, Linn., *Michelia champaca*, Linn. and *Anthocephalus indicus*, Rich. suggests that these trees were familiar to the Kushana sculptors from personal observation. It may be objected that sometimes sculptors carve a design which is popular and fashionable. However, an animal or tree becomes a motif in sculpture only when the people including the sculptors are familiar with it in their daily life. In these Kushana sculptures of Mathura we see figures of lions and antelopes and do not see any tigers for the simple reason that the tiger had not come so far north at that time, and lion was a common carnivore. When a design is carved by sculptors who are not familiar with the original, the result is crudeness. Such a crudeness we see in the 'Asokā Dohad' figures depicted at Begram in Afghanistan which have been brought to light by Hackin. These figures were carved during the Kushana period and are crude copies of the Mathura figures of Asoka tree and at once reveal that the artists were copying some one else and had not seen Asoka tree in its natural surroundings.

Past and Present Distribution of Saraca indica and other Mathura Trees of Kushan Period—The presence of Indo-Malayan tropical trees like *Saraca indica*, Linn., *Michelia champaca*, Linn., *Anthocephalus indicus*, Rich., (Syn. *A. cadamba*, Miq.), and *Mesua ferrea*, Linn. as far north-west as Mathura about 2,000 years ago is established from sculptures of the Kushan period discovered from various localities in Mathura district.

Present Restricted Distribution of Saraca indica, Linn. and other Kushan trees—At present *Saraca indica*, Linn. has a much more restricted distribution. It is found only in the evergreen forests of the west coast of Bombay, Northern Circars, Khassia Hills, lower elevations of Himalayas from Kumaon eastwards, Chittagong, Upper Burma, Arakan, Tenasserim, Ceylon, Andamans and Malaya.

As regards the present distribution of *Michelia champaca*, Linn. Hooker mentions that "It is found wild in the forests of the Temperate Himalayas from Nepal eastward, Nilgiris, Travancore, Pegu, Tenasserim and Java". Haines mentions Western Ghats, Singhbhum, Palamau, Neterhat and Mayurbhanj in Bihar in addition to the places mentioned by Hooker, and also states that at other places it is cultivated.

Anthocephalus indicus, Rich. is found in natural condition in North and East Bengal, Western Peninsula, Ceylon, Andamans, Pegu, Malaya, Sumatra and Borneo, and elsewhere it is cultivated. It is absent from the dry areas of the United Provinces, Delhi and the Punjab. Even in comparatively wet districts of Oudh it is rarely found cultivated in gardens, and if you inquire from people you will find very few who have seen a Kadamba tree, except in mythological pictures of Krishna. The fourth tree which appears to be *Mesua ferrea*, Linn., the Nagsura tree is found in Eastern and Northern Bengal, Assam, Eastern Himalayas, North Behar, Orissa, Western Ghats, Burma and Andaman Islands. Elsewhere in India it is cultivated only.

From the above it is apparent that the present distribution of these four trees is almost co-terminous, and the distribution of *Mesua ferrea*, Linn. and *Anthocephalus indicus*, Rich. falls in line with that of *Saraca indica*, Linn. A glance at the rainfall map of India, and neighbouring countries shows that these trees are found in the evergreen forests of India, Burma, Ceylon, Malaya and Sumatra with a rainfall of over 80 inches and particularly *Saraca indica*, *Mesua ferrea* and *Michelia champaca*. *Saraca indica* is the most moisture loving of all these four trees, and then *Michelia champaca* followed by *Mesua ferrea* and last of all *Anthocephalus indicus* which can be cultivated in comparatively dry areas. Even in districts of Oudh with a rainfall of 40 inches *Saraca indica* grows with great difficulty in gardens as it is very susceptible to hot winds. It is commonly confused with another cultivated South Indian tree, *Polyalthia longifolia*, and even Sanskrit scholars who ought to know better call this much less attractive tree as Asoka. This shows how completely the people of these parts have forgotten the real Asoka tree due to its extinction in these parts centuries ago. There is only one well-grown tree in Khusroo Bagh at Allahabad and 2–3 stunted trees in Sikandar Bagh at Lucknow. Khusroo Bagh is a Moghul garden with a high protecting wall and in Sikandar Bagh it is growing in a sheltered corner surrounded by other trees.

From the present natural distribution of these four trees and particularly that of *Saraca indica*, Linn. one can safely infer that about 2,000 years ago, Mathura district which has almost become a desert with an average rainfall of about 24 inches had a minimum annual rainfall of 80 inches, or more. It is probable that Mathura and North India enjoyed a comparatively wet and mild tropical climate. This is inferred not only from the presence of tropical trees like *Saraca indica*, *Michelia champaca* and *Mesua ferrea*, but also from the frequent use of lotuses in architecture. In Mathura sculptures we find lintels carved with lotus buds and flowers, and women wearing lotus garlands. We also find a female figure standing on lotuses (the so-called Shri Lakshmi of Dr. Anand Coomarswamy), with lotus buds, flowers and leaves carved at the back.

Dress of Mathura people in Kushan period—We also find that the men and women were practically undraped ; while men wear only a brief loin-cloth around their hips, women have an ornamented girdle or a loin-cloth only around their waists. That women of ancient India kept their breasts naked or at best covered them with a thin piece of cloth is also apparent from the descriptions of toilet of women left by Kalidasa in 'Ritusamhara' in which he has described the reasons. In his description of summer he writes, "Young women smear their bosoms with sandal-paste and cover them with snow-white garlands of flowers, and wear girdles of gold on their hips". Such an existence is only possible in a humid tropical climate similar to that of present day Assam. The heavily clad figure of Kanishka who came from the colder north may also be contrasted with the semi-nude male and female figures of men of Mathura.

The resemblance of the dress of Mathura women with the women of present day tropical island of Bali who are also undraped from waist upwards is apparent. So the comparative nakedness of the women of Mathura in the Kushan period is not due to sensuousness of the inhabitants, but an adaptation to a mild tropical climate. The wet nature of the country is also proved from the figures of women shown bathing under water-falls. Water-falls are

found only in rocky places with heavy rainfall. The frequent use of aquatic animals like fish and alligator in decoration of pillars and gateways, and of domestic animals like elephants who flourish in swamps also point in the same direction.

Past Distribution of Saraca indica, Linn.—The past distribution of *Saraca indica*, Linn. in Northern India, the region from which it is absent now is established from Archaeological evidence and literary evidence from ancient Sanskrit literature.

1. *Archaeological Evidence*—*Saraca indica*, Linn. was the most popular tree with the Mathura sculptors of Kushan period, and the presence of this tree in Mathura from C. 1. A.D. to C. 176 A.D. is well-established from the railing pillar "Woman and Tree" figures of Mathura. In the sculptures of Sanchi in Central India which date from first century B.C., we also find this tree. In Sanchi sculptures we find a bracket which has been wrongly described by Sir John Marshall as a *bignonia* tree bracket. The shape and arrangement of its leaves and structure of its flowers show that it is an Asoka tree. We also find a beautiful figure of a woman under an exquisitely carved Asoka tree in sculptures from Bharhut in Nagod State, Central India. The Bharhut sculptures date from the period of Sungas from 112 B.C. to 72 B.C. In a Ramayana panel of a Gupta temple at Deogarh near Lalitpur in Jhansi district, we find the branches of an Asoka tree. Guptas ruled from 320 A.D. to 490 A.D. and in those days this tree was probably flourishing in the present arid district of Jhansi. We also find Asoka tree depicted in Ajanta paintings dating from 500 A.D.

Evidence from Sanskrit Literature—We find numerous references to Asoka and Nipa (*Anthocephalus indicus*) in Sanskrit literature particularly in Ramayana, Mahabharat, works of Kalidasa and Harsha's 'Ratnavali'. An author usually incorporates the description of those tree which he observes, and from this point of view the references we find to Asoka and Nipa in ancient Sanskrit literature are valuable in ascertaining the distribution of these trees.

Macdonnel has concluded that the kernel of Ramayana was composed between C. 200 B.C. and C. 500 B.C. In Ramayana it is mentioned that Sita was kept by Ravana in an Asoka grove in Lanka. We also find references to Asoka, Punnag (Nag-kesar, *Mesua ferrea*) and Kadamba in Aranya Kand where we find the description of a forest near Panchvati where Rama, Lakshman and Sita lived during their period of exile. Panchvati has been located near present day Nasik on the west coast of Bombay. Asoka trees are still found in Ceylon and West coast of Bombay. In Kishkinda Kand we find Rama expressing his grief to birds, animals and trees of the Panchvati forest after the abduction of Sita and requesting the sorrow-allaying Asoka tree to give him relief in his misfortune. When Rama returns to Ayodhya, after rescuing Sita from Ravana it is described that he bade farewell to his friends and allies and retired in an Asoka-vatika.

Though it is difficult to be precise about the date when the epic Mahabharata was written and the place of birth of Vyas historians generally agree that it was composed between C. 500 B.C. and C. 400 A.D. From the descriptions which the author has given one may safely presume that he lived somewhere in the area between the Sarasvati and Ganges. In 'Van Parab' in which the exile of the Pandavas is described we find references to Kadamba trees in Dwait forest. This forest existed in the region covered by the present districts of Saharanpore and Dehra Dun. The author writes, "The Pandavas entered the beautiful forest known as 'Dwait Ban' and there Yudhishtira saw the trees of Sal, Tal, Mango, Kadamba, Mahua and Arjan". The presence of Sal (*Shorea robusta*) shows that this forest was sub-Himalayan. Similarly we find a reference to Kadamb tree in Kamyak forest which existed south-west of Delhi and it is likely that the existing Kadamb forests in Mathura and Bharatpore are remnants of this ancient Kamyak forest. The king of Sindh is passing through Kamyak forest on his way to Salva country and his messenger thus addresses Draupadi, the spouse of Pandavas.

"Who art thou that, bending down the branch of the Kadamba tree, shinest lonely in the hermitage, sparkling like, at night, a flame of fire shaken by the breeze, oh well-browed one! Exceedingly art thou vested with beauty, yet nothing fearest thou here in the forest".

Though it has not been historically established as to when Krishna lived, we at least know that the authors of the epic Mahabharata were familiar with jungles of *Anthocephalus indicus* in the neighbourhood of Mathura and that is why we find Krishna so intimately associated with this tree. That this is an accurate record is proved from the remains of Kadamb forest in Mathura.

We find numerous references to Asoka tree in Buddhist literature. Among the trees associated with the miraculous birth of Buddha which took place in Limbini garden near Kapilvastu, we find Asoka tree mentioned along with Mango, Dhak (*Palas*) and Sal tree. In the description of Buddhist sanctuary Punnabhadde near Campa we find Asoka tree conspicuously mentioned. As Ananda Coomarswamy quotes, "This sanctuary was encompassed round by a great wood. In the wood was a broad mid-space and therein was a fine Asoka tree".

There is a concensus of opinion among most historians that the famous dramatist Kalidasa was a native of Malwa, and was a contemporary of Chandra Gupta II, Vikramadatiya and lived between C. 375 to C. 455 A.D. Kalidasa has left us accurate descriptions of the ancient city of Ujjain and from his accounts it is evident that Asoka tree was common in and about Ujjain. In his play Malvikagnimitra the heroine Malvika performs the 'Asoka-Dohad' ceremony by kicking the Asoka tree with her left leg. In his Meghadutam (Cloud Messenger) he gives an accurate description of a journey of a cloud, from Central India to the Central Himalayas. From the accuracy of description of places and vegetation it can be safely concluded that Kalidasa was a much-travelled man who knew not only his favourite city of 'Ujjayini' in the land of Avanti but had also seen Narbada river winding at the foot of the Vindhya hills, the town of Vidisa (Bhilsa) the stream of Vetravati (Betwa), the plains of Kurkshetra near present day Meerut, the shrines of Kankhal near Hardwar where Ganges descends into the plains. In his description of the Himalayas he mentions the Chir Pine (*Pinus longifolia*) and Deodar (*Cedrus deodara*). Though he places the town of Alaka near Kailash in Tibet in the trans-Himalayas, his description shows that this place was not more than 6,000–7,000 feet high, as is evident from his description of vegetation. In his description of the toilet of the women of Alaka he mentions, Lodhra (*Symplocos racemosa*), Sirisha (*Albizzia* sp.) and Kurubaka (*Barleria cristata*) all of which grow below altitude 6,000 feet. So it is likely that Alaka was not far from Kankhal and may be some place in outer Garhwal on the pilgrim route to Badrinath or Gangotri.

Kalidasa describes Nipa forests (*Anthocephalus indicus*) near Nichai hill near Sanchi, and along the banks of Reva (Narbada river). He also describes "a red-bloomed Asoka tree with trembling leaves" in the town of Alaka in the Himalayas, which was possibly in outer Himalayas of Garhwal. Asoka occurs at present in the lower elevations of the Himalayas eastwards of Kumaon. In the age of Kalidasa it was growing further north as far as outer Garhwal above Hardwar.

In the celebration of seasonal festivals of spring in ancient India we find numerous references to Asoka. There was a favourite festival celebrated in spring known as "Asoka-pushpa-prachyika", gathering of Asoka flowers when young women collected Asoka flowers. Vatsayana, the celebrated author of Kam Sutra the Hindu encyclopaedia of sex probably lived at Ujjain in fourth century A.D. in the reign of the Guptas. In his description of popular festivities (Samasyakrida) he mentions seventeen seasonal festivals including Asoka festival and Kadamba festival, when people fought mock battles with ball like Kadamba flowers.

We find a description of worship of Asoka tree at Kanauj during the celebration of spring festival, Madan Utsav, in Harsha's Ratnavali which was written about 600–648 A.D. It is also mentioned that the citizens of Kanauj decked themselves with flowers of Asoka.

Remnants of 'Kadamba' Forests in Mathura—Another reason which supports the presumption of presence of Asoka forests in Kushan Mathura is that we still find remnants of Kadamba forests in Mathura district. We find an unmistakable 'Kadamba' tree in one of the railing figures from *Kankali Tila*. As compared with 'Kadamba' tree 'Asoka' tree was much more frequently sculptured by the Kushan sculptors, and consequently it can be deduced that *Saraca indica*, Linn. was a commoner tree than *Anthocephalus indicus*, Rich. and very probably there were wide-spread forests of this tree. While the more moisture-loving *Saraca indica* has disappeared on account of increasing desiccation, the comparatively more drought-resistant *Anthocephalus indicus* has survived in some swampy pockets. Sir Digby Drake-Brockman who compiled the Gazetteer of Mathura district describing the vegetation writes—"Many of the villages stand out devoid of trees ; but near others, especially those of old standing there are fairly large commons known as 'rakhya or Kadamb' woods (Kadamb khandi). The poorer specimens of these are merely uncultivated land covered with 'karil', 'Pilu', 'hins' and other jungle shrubs ; but in the better ones there are large 'kadambs' (*Anthocephalus cadamba*) and other fine jungle trees which make these 'rakhyas' look like pieces of real forest. Many of these are of considerable size".

These so-called 'kadamba rakhyas' or 'kadamb khandis' are barren waste lands supporting only xerophytic shrubs and herbs used as pasture land by villagers. While the 'kadamba' trees have vanished, the name has lingered as a vestigial feature reminding one of the wet days of Mathura when it was surrounded by luxuriant tropical evergreen forests. Mr. Babu Lal Gupta who has made a detailed study of the vegetation of the 'Brij' the Bharatpore–Agra–Mathura area reports that Kadamba trees are still planted near some temples and along road-sides in Mathura. He also found a remnant of Kadamba forest in Keola Deo Jungle near Bharatpore, about six miles from that city in a low-lying swampy area in which water is found over an area of several miles throughout the year. Some of these trees are as much as one hundred years old, and Mr. Gupta is of opinion that these are possibly the remnants of Kadamba forests on the verge of extinction. The forest at Chhata which is described in the gazetteer as the largest Kadamba forest contains very few Kadamb trees now and is mostly fitted with Neem and Babul tree. In 'Koklia Ban' at Bathan almost all the Kadamb trees have disappeared in the last 30 years, and old inhabitants of Bathan say that about 30 years ago it was all a Kadamb forest. Large empty spaces have appeared in the Kadamb forest at Nandgaon as several Kadamb trees have died off. These observations of Mr. Gupta show that Kadamb trees in 'Brij' area are on the verge of extinction due to lack of sufficient moisture and this may mean the end of the ancient 'Kamyak Ban' of Mahabharata in the near future.

From Evergreen Tropical Forest to Desert—This is how Sir Digby Drake-Brockman who had a wide knowledge of Mathura–Agra area describes the present day 'Brij' area – "The beauties of Brij Mandal have formed the theme of many poets' praise in song. But the first aspect of the holy land could not fail to disappoint the student of Sanskrit literature ; who had been led to anticipate grassy swards and smiling prospects ; and the impression upon the mind of any chance traveller during the hot and cold seasons of the year is that of a vista of depressing flats, blurred by a dense and cloudy haze and unrelieved by the grateful shade of trees".

The present vegetation of the 'Brij' country is xerophytic, and is not very different from that of the Rajputana desert. The average annual rainfall of Mathura is 23·61″ which is the lowest in the United Provinces, and that of Agra is 25·1″. After the close of cold months, temperature rises rapidly in the month of March and humidity goes down. High temperature

shooting up to 114°F. in the shade and desiccating hot west winds from the rocky Aravalli hills and sandy deserts of Rajputana, often accompanied by dust-storms in May and June have produced a typical desert vegetation of xerophytes with adaptations against dry conditions and with devices for conserving moisture. The commonest trees are the leafless Karils (*Capparis aphylla*, Roth.) the ungraceful Pilu (*Salvadora oleoides*, Dcne.) with tough leathery leaves, the ubiquitous Babul (*Acacia arabica*, Willd.) the feathery-leaved Chonkar (*Prosopis spicigera*, Linn.), the Hingot (*Balanites aegyptiaca*, Delile), Pasendu (*Diospyros cordifolia*, Roxb.), Pilkhan (*Ficus cordifolia*, Roxb.) and several species of *Tamarix* with reduced scaly leaves. The waste spaces between the villages are more or less bare with occasional patches of Jharber (*Zizyphus rotundifolia*, Lamk.), *Salvadora persica*, Linn. and Dhak (*Butea frondosa*). The rocky areas are covered with hardy shrubs like Dho (*Anogeissus pendula*, Edgew.). Among the herbaceous vegetation we find such interesting xerophytes as Kheep (*Leptadenia spartium*, Wight) with erect cylindrical almost leafless branches, the spiny Jawasa (*Alhagi camelorum*, Fisch.), and the deep-rooted Ratanjot (*Arnebia hispidissima* DC.). In the shade of the prickly bushes of *Capparis sepiaria*, Linn. grows the inconspicuous drought-resistant Gillirgitta (*Ceropegia bulbosa*, Roxb.), whose bulbous perennating stem is roasted and eaten by cowherds. Besides these we find succulent herbs like *Portulaca oleracea*, Linn. and *Salsola fœtida*, Del. which store up a large quantity of water in their leaves, and rosette plants with tough perennating root-stocks like *Boerhaavia diffusa*, Linn. and *Euphorbia thymifolia*, Linn.

The 'Brij' country which was covered with luxuriant evergreen tropical forests of *Saraca indica*, *Mesua ferrea* and *Anthocephalus indicus* about 2,000 years ago has completely changed now. The swampy jungles which were the abode of the rhinoceros, the wild elephant, and the antelope have disappeared, and in their place we find sandy waste haunted by flocks of black buck and deer deluded by mirages of rivers and lakes which exist no more. The ponds and lakes which were filled with pink and white lotuses and visited by ducks and wild geese providing inspiration to the Kushan sculptors, have completely disappeared, and in their place we see ravines, sand dunes and parched plains which have become the rendezvous of the grey partridge (*Franco-linus pondicerianus*, Gmelin) quail (*Coturnix coturnix*, Linn.) and the sand-grouse (*Pterocles exustus*, Temm. and Lang.) the typical birds of the Rajputana desert.

Famines in Brij—The effect of desiccation on the flora and fauna has been described above, and man himself cannot escape the consequences of a change from which the plant and the beast have suffered. Desiccation which was the result of decreasing rainfall slowly changed the face of the land. Effects of drought on man in the form of famines were evident in this area as long ago as 1601 A.D. Big famines occurred in 1631 and 1645 A.D. From 1825 onwards records of droughts and famines are available, and we find that this area was ravaged by famines in 1837–38, 1860–61, 1868–69, 1877–78, 1896–97, 1899–1900, 1905–06 and 1907–1908 A.D. Famines would have continued had the Government not intervened by introducing canal irrigation.

The challenge which nature has thrown before man in the form of desiccation due to decreasing rainfall has an answer. Drought can be countered by artificial irrigation and has in fact been countered by artificial irrigation. The problem of soil erosion and conservation of soil can be solved by afforestation of waste land, and by regulating the drainage of rain-water by building embankments. However to achieve quicker results it is necessary to put a check upon the destructive activities of man, goat and the camel. By regulating pasturage and promoting the growth of fodder crops the growth of soil holding plants can be encouraged and the destructive result of erosion and deforestation halted. Man should no longer remain an accomplice of this rape of the land, and should resolutely face this problem which has remedies. While lopping of trees should be prohibited, it would be worthwhile banishing the goat, the

arch enemy of young trees from the land of Krishna. The hardship to a few people will be more than compensated by benefits which will accrue to the area as a whole.

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ON THE OCCURRENCE OF *BAMBUSA POLYMORPHA* MUNRO IN BORI VALLEY, HOSHANGABAD DIVISION, MADHYA PRADESH

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Bambusa polymorpha, the handsome, tufted bamboo, is a native of Burma, East Bengal (Pakistan) and Sylhet (Assam). Kurz says it is common in the upper mixed forests of the Pegu Yoma and Martaban, where it grows on permeable siliceous sandstone. It is abundant throughout the moister types of the upper mixed deciduous forest in the Pegu Yoma particularly on the lower slopes of hills and in well-drained valleys, where it flourishes best and reaches its largest dimensions on deep, moist fertile loam (Troup). It also occurs in Martaban in the Salween valley and locally in other places in Burma, as for example in the Thaungyin drainage in Tenasserim and in a few places in the Yaw drainage in upper Burma. The bamboo is associated here with teak, *Xylia dolabriformis* and various other species, all of which are generally of excellent growth quality standing as they do on deep, rich, well-drained soil. *Bambusa polymorpha* was introduced into various parts of Madras state a few years ago ; it has been grown, experimentally, at Dhoni in Palghat division (altitude 300 feet) on well-drained loamy soil, at Topslip in South Coimbatore division (altitude 2,500 feet) on well-drained clayey soil, at Nilambur (altitude 100 feet) on reverain alluvium, at Begur in Wynaad division (altitude 2,000 feet) on black loamy soil, and at Kannoth in Wynaad division (altitude 300 feet) on red loam with laterite nodules. It has also been grown in North Salem as well as in parks and gardens elsewhere. There is a plantation of the bamboo in New Forest, Dehra Dun and also in other places.

In South India, the rainy season, July to November, is generally the period of its vigorous growth and the resting period is the dry season – February to April or May – depending upon the date of the pre-monsoon showers. The main difficulty with this bamboo in elephant forests is that these animals are attracted by it, and they damage it badly.

The object of this note is to record the existence of *Bambusa polymorpha* in a wild state in the famous Bori valley, Hoshangabad division of Madhya Pradesh This interesting fact, and one of considerable importance to those concerned, came to light when the Forest Utilization Officer Shri Wali Mohamed, and the writer were perambulating the forests of Bori valley in considerable detail with a view to examine the peculiarities of the natural regeneration of teak and the causes which bring about to its phenomenal success in some places when we resort to canopy manipulation and cutting back of the male bamboo (*Dendrocalamus strictus*), but to total failure in other places inspite of following the same treatment. During our forest perambulation in the interior of the Bori valley, we saw an old man who belongs to one of the local tribes called *Korku* carrying a piece of bamboo, which looked quite different from *Dendrocalamus strictus* which is the common local bamboo. On being questioned about the bamboo he was carrying the old man stated that it is known by the local (*Korku*) name "Narangi" *bhas*, and that it grows in the forest. On examination of the forest in the vicinity, the bamboo was found growing wild on either side of a small stream which forms the boundary between compartments 40 and 43 of the Bori felling series, very close to where the stream joins the Bori river. The greyish tomentose culms, the straw coloured internodes and the handsome tufted appearance of the clumps left little doubt in the mind of the writer about the identity of the bamboo (see figure) but one peculiarity observed was that the internodes, of some culms, are extra long for *Bambusa polymorpha*, being up to 2 feet•5 inches. The walls of such culms are also comparatively thin. This condition, however, was found only

in the case of a few culms, but the large majority of them are thick walled and have shorter internodes than what has been described above. The thin walled culms with long internodes, have also very thin nodal septa ; in fact so thin are these that they appear translucent when held up to light.

There is no reference to the presence of this bamboo in the Bori valley either in the compartment histories, or in any of the forest journals of Bori forest which were available. Its occurrence only in this place and that too in patches which are a few hundred square yards in extent, suggests that the bamboo was probably introduced into this area long ago and lost sight of. Some old *Korku* men, who are presumably 70 years old or more, from whom careful enquiries were made to ascertain whether any information was handed down to them by their elders about the planting of this special kind of bamboo, said that they did not know anything about the existence of this bamboo until a few years ago when one among them accidentally noticed it and told the others about it. The very irregular shape of the area covered by the bamboo patch, the haphazard espacement of the clumps within the patch which we examined and the fact that a couple of clumps are standing even in the bed of the stream, indicate that the patch is not man-made, but probably the bamboo crop in it arose after a natural seeding. It is, therefore, probable that the present crop belongs to the second generation which emerged after the older crop had flowered. There is, however, no local information about the occurrence of such flowering, but it is likely that the flowering was not noticed by any one. Any how, the existing bamboo crop is most probably of natural origin, and it is not a plantation.

Bambusa polymorpha is thriving remarkably well in this locality. The culms are easily 60 feet or more tall, handsome, tufted, and the bamboo patches are slowly, though

surely, spreading. A nearer description of the factors of this locality would, therefore, be of interest to foresters.

The basal rock formation of this locality belongs to the *Damuda* series of the *Lower Gondwana* system, with a capping of deccan trap in the north. Sandstone, conglomerate and deccan trap are the commonest rocks found in the compartments 43 (area 322 ac.) and 40 (area 334 ac.). The soil, where *Bambusa polymorpha* occurs, is a rich alluvium and holds abundant moisture. The flats which adjoin the river to its north are gently undulating, and these end in abrupt steep and precipitous hill slopes towards the north. Here, however, *Bambusa polymorpha* does not exist.

The tree crop in the locality where *Bambusa polymorpha* is found contains the local best quality teak, which is being called here for convenience as I Quality ; this quality is confined to the banks of Bori and Sonbhadra rivers ; elsewhere the crop deteriorates to low II Quality. The tree crop is fairly dense ; the commonest associates of teak found here are *Terminalia tomentosa*, *Ougeinia dalbergioides*, *Adina cordifolia*, *Bassia latifolia* and one or two others. The proportion of teak in the crop is quite high but pure patches of it are uncommon. Scattered regeneration is present.

It was considered desirable to bring these patches of *Bambusa polymorpha* under permanent preservation, and steps to implement the above have, I believe, been taken already. In view of the ease with which this bamboo can be propagated with rhizomes and the fact that it is thornless and fit for all-round use, artificial regeneration of the bamboo on a large scale in this area, which seems to be eminently suited to it, may be profitable and really worth while.

TREATMENT OF WATER-LOGGED AREAS

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1. *Extent of damage*—About 5,500 acres of water-logged areas occur along the Western Jamuna Canal, particularly where it runs in embankment, in Karnal district, about 1,600 acres along the Agra Canal likewise and between it and the river in Gurgaon district and about 3,000 acres (besides the same acreage of semi-water-logged areas under marginal cultivation) in Ambala district. Lot of such areas occur elsewhere also in the State.

2. *Causes of damage*—Water-logged areas lie in flat country, and have been lost to cultivation through the cumulative rise in the sub-soil water-table, as a result of long-continued canal irrigation or seepage from torrents or drains having weak or no outfall or from canals running in embankment. As an instance, the main water-logged block of area in Ambala district lies along the Sirhind Canal running in embankment near Chamkaur village. Also, an old Escape takes off from the canal at the place. And a nullah (named Budha) begins from the Escape. This nullah is a very old bed of the Sutlej river now flowing close by. It now serves as a drainage, joining the Sutlej some distance below Phillaur town. There is generally a small amount of water flowing down it, but its course is impeded by rushes and weeds which prevent drainage water passing away freely ; and, consequently, during heavy rains a large area of the adjacent country gets badly flooded. In many places it has no well-defined channel ; but its alignment is indicated by swamps. The Canal Department has constructed some small seepage drains which carry some of the water from the swamped areas away to lower parts of the Budha nullah. These drains, however, cannot completely drain the swamps.

The harmful effects of the rise of water-table are evident in two forms – the saturation of the root zone or water-logging (*sem*) and the concentration of salts (*thur*). The principal vehicle for the upward movement of salts is probably the water moving upwards from a high water-table under the influence of capillary pressure and evaporation. Usually, the saline condition of soil (known as *thur*, *shor* or *kallar*) is a preliminary stage of water-logging (or *sem*) ; the soil is affected by salt efflorescence at the surface which, consequently, turns white, ash-coloured, black, brown or oily in appearance.

3. *Theory of water-logging*—Water-logging is injurious to the healthy growth of plant-life due to excess of water or of salts (*Shor* or *kallar*) brought up by capillary action due to nearness of sub-soil water-table below. The Irrigation Research Institute, United Punjab, investigated into the movements of salts in the soil profile. The Punjab alluvium consists of a shallow soil crust overlying sand of unknown depth. Alkaline or acid salts (mostly sodium) accumulate in the profile, and their movement towards the surface of the soil with a rising water-table is believed to be of considerable practical importance. Particularly in the drier tracts, there occur vast stretches of land where, on account of high salinity or alkalinity, the cultivator finds it uneconomic to grow agricultural crops ; and the saline areas are increasing, particularly in the canal irrigated lands.

"Saline soils are formed in arid or semi-arid climates where the precipitation is less than the quantity of moisture lost by evaporation. There is an accumulation of salts in the surface layer and most commonly this happens when there is a high water-table and low humidity resulting in upwards movement of water by capillary action and the salts are left accumulated in the surface layers as the water evaporates. In many cases the high water-table

is caused by the existence of an impermeable layer or hard pan in the sub-soil. It has been shown in the Punjab that when shallow irrigation is given, salts already present in the soil are washed down and form a zone of accumulation at a depth of 3 to 4 feet from the surface. If more water is supplied this may move downwards but if the land is left fallow and no irrigation is given, then the zone of accumulation moves to the surface of the soil resulting in the formation of a saline soil. Similarly the process of formation of alkaline soils, according to de Sigmond, is also a bit complex. The colloidal clay particles in the soil behave as large complex anions and possess the property of absorbing cations of the various base elements like calcium, magnesium, sodium and potassium. Normally in the alkaline tracts soil colloids are charged with calcium and magnesium ion. Calcium when present on the colloidal complex of the soil helps to maintain its crumb structure whereas the colloidal particles charged with sodium or potassium have the property of getting dispersed in water and they impart to the soil the undesirable properties of stickiness and impermeability. If the salts in saline soils are rich in sodium salts (which is very common) and poor soluble calcium salts the sodium cations will displace the calcium cations from the colloidal clay particles of the soil. It is this process of replacement of calcium and magnesium ions on the colloidal complex of the soil by sodium or potassium-ions through base exchange which is termed as Alkalization".

"After the processes of salinization and alkalization described above have been completed the next step in the evolution of alkali soils consists in desalinization or the washing out of the excess of soluble salts from the alkalized soils. This may take place on account of flooding, natural or artificial. By this process the soil becomes poorer in soluble salts and the soil colloids which are charged with alkali-cations disperse on account of the removal of the coagulating effect of the electrolyte or the salts".

"As a result of the above stages de Sigmond has divided the saline and alkaline soils into the following four classes :—

(1) Saline soils,

(2) Saline alkali soils,

(3) Desalinized or leached alkali soils,

(4) Degraded alkali soils.

"Saline soils have pH value of about 8·5 to 10. In the case of leached alkali soils on account of the dispersion of the alkalized colloidal clay particles due to the removal of the coagulating effect of salts the permeability of these soils both to water and air is greatly decreased. Even after many showers these soils may get wet only a part of an inch deep. This is due to the swelling of colloids and the resulting increase of volume which closes all the pores and makes the soil impervious. The characteristic features of typical alkali soils are that they have a compact structure, are almost impermeable to water and are strongly alkaline in reaction and if the soil is mixed with a large volume of water one finds a turbid solution which does not get clear even after months. The fine soil particles in these soils are often washed downwards and form an impermeable hard pan in the deeper layers of the soil".

"Properties of saline and alkaline soils that adversely effect plant growth can well be recognized if the above processes are fully appreciated. Plants growing in alkali soils usually suffer from lack of moisture due to impermeability of the soil, lack of oxygen for roots, which again is due to compactness of the soil, and corrosive and toxic action of certain substances such as sodium carbonate and soluble aluminates. The latter are usually formed when the pH value of the soil is over 10. The alkaline soils are poor in nitrates because nitrification by the soil bacteria is greatly restricted above pH 7·5. Plants growing in alkali soils often suffer from many nutritional disorders such as lack of iron, calcium and phosphorus. This may be due to the unavailability of certain elements to the roots in alkaline surroundings".

"Plants grown in saline soils are known as halophytes. Some halophytes are able to secrete salt from the surface of their leaves and sometimes their stems through hydathodes. Morphological studies have shown that halophytes have generally a tendency towards succulency and develop thicker leaves and stem and that they have a more pronounced palisade parenchyma, smaller intercellular spaces and often diminution in the number of choloroplasts".

4. *Treatment* – (*a*) *Water-logged areas*—Results of afforestation (with *Eucalyptus rudis*) of Pakhowal *jhil* in Daphar Range of Depot West Forest Division (West Punjab) during 1932-38 furnish a successful demonstration of the value of tree planting in water-logged areas. Creation of permanent tree belts (*Eucalyptus, Salix*, etc.) along the canal, torrent or drain is calculated to reduce appreciably the water-logging hazard. But where it is deep, or where the land is required without delay to be restored to cultivation, the water-logging can be remedied by digging storm water and seepage drains, lining of channels and tube-well pumping. Storm water drains prevent or remove accumulation of water in low-lying lands. They are also helpful in reducing direct damage to crops by flooding. Seepage drains, depressed below the water-table, flow continuously and help to control the depth locally. The excess water should be drained off through a system of seepage drains and channels with a clear outfall into the nearest torrent or river. This has been successfully tried by the writer over a large area between the Upper Jhelum Canal and the Jaba Torrent in Gujrat district (West Punjab). After level-survey of the affected area, the main channels (4 × 3 feet) should be aligned about 4 to 8 furlongs apart ; and subsidiary drains (3 × 2 feet) should run between, and at right-angles to, them, espaced about 1 to 2 furlongs apart. Then between these, trenches (1 × 1 foot) should be dug at right-angles and espaced 100 feet apart. The ground contours would determine all the alignments correctly.

(*b*) *Saline areas*—A remedy recently developed for *thur* is the leaching of the land by the application of large quantities of water.

Afforestation—As an essential preliminary, the proposed area must be protected against damage under the closure-scheme. The following species should be tried, as below, for water-logging on mounds encircled by trenches 12 × 6 inches in section or on ridge along trench ($1\frac{1}{2}$ × 1 feet in section). The trench should, if practicable, be continuous, with an outflow into some drainage channel to help drainage of the excessive water. The plant on the mound or ridge will be set high so as to be out of the stagnant water and free from excessive moisture. The plant species suggested below for water-logging are all more or less high transpiring ones :—

(i) *Eucalyptus robusta* (Australia), *rostrata, rudis*—Transplants to be raised in small bottomless earthen pot in a nursery. Suitable for heavily water-logged areas. *Robusta* would be the best.

(ii) *Taxodium distichum* (Exotic timber tree)—Transplants : For heavily water-logged areas.

(iii) *Salix babylonica* – *majunu, tetrasperma* – *bed* (willows)—Branch cuttings : To be embeded 3/4ths into the ground, with both ends having slanting cuts. For moderately water-logged areas.

(iv) *Eugenia jambolana* (*jaman*)—Transplants : semi-water-logged areas.

(v) *Mesembryanthemum crystallinum* (Exotic – Africa)—It is known as 'the ice plant', and is believed to absorb an extra-ordinary amount of alkaline salts from the soil – Both sowing and planting may be tried in the saline (*kallar* or *thuhr*) areas.

(vi) *Salsola fœtida* (*Lana, shora*)—A large shrub for saline soil : sowing.

(vii) *Suaeda fruticosa* (*Lana* – for *sajji*)—Sowing. A shrub for saline soils.

(viii) *Tamarix pubescens* (Exotic – Russia)—Will not grow on nonsaline soils – Branch cuttings.

(ix) *Acacia arabica* (*Kikar, Babul*)—Sowing : suitable for saline soils which are moist.

(x) *Acacia catechu* (*Khair*)—For swampy ground.

(xi) *Butea frondosa* (*Dhak*)—Sowing and stumps : suitable for saline and swampy soils, preferring sand.

(xii) *Tamarix articulata* (*Farash*)—Branch cuttings : semi-water-logged and saline (*kallar* or *thuhr*) areas. Its needles are saltish to taste due to the high content of chlorides and sulphates. Examinations of the soil profiles under farash by the United Punjab Irrigation Research Institute in 1936 indicated presence of high soluble salt content in the top horizons, and that a fairly high degree of alkalization is tolerated by this species.

(xiii) *Sapium sebiferum* (The Chinese Tallow – *Tar Charbi*)—Swampy areas.

(xiv) *Arundo donax* (*Nara*)—Swampy areas.

(xv) For marshy places, the species found successful in other States are : Teak (on ridges), *E. robusta* and *rudis* and *Lagerstrœmia flosreginæ* in Madras, *Casuarina equisetifolia* in Orissa, *Barringtonea acutangula* in Assam and *Bischofia javanica* in Bengal.

Note :—For species other than *Ecualyptus* : pot planting may also be tried. The earthen pot should be broader at the base than at the top, with a view to its being pulled up easily while transplanting.

Note :—*Banana* (Plantain) groves are believed to overcome water-logging on account of the water-sucking characteristic of this succulent fruit plant. The *kela* leaves have high rate of transpiration.

5. *Works in progress*—In Gurgaon district (Palwal), silvicultural experimental afforestation of a plot of semi-water-logged, saline (*thur*) area is under way. In Karnal district, besides sporadic afforestation by the Forest department of some semi-water-logged areas, the Irrigation (P.W.D.) department is experimenting on the reclamation of water-logged and saline lands at two places, viz., Indri and Nissang, as below :—

(*a*) *Indri*—It lies between the Main Line Lower Western Jumna Canal and Sangoha drain, and within a large undulating tract of about a lac acres of depression comprising 11 villages. It contains two trough like lakes (*jhils*) ; the rest of the area has water-table 1–2 feet above ground-surface during the monsoon, and 1–5 feet below ground-level during winter, with an incrustation of salt at the natural surface. The total net area under reclamation is 2,489 acres, scattered over all the 11 villages. A scientific soil survey has revealed presence of high salt contents and pH values. Natural vegetation is mostly *dab* grass (*Eragrostis cynosuroides*) and date trees. The Government has approved of the objects to be achieved, viz., lowering of the water-table, leaching down of salts and conversion of the sodium – clay into calcium – clay. Only 1/4th of the area is under marginal cultivation, the rest being all unculturable *banjar*. The area has been requisitioned from the *zamindars* for a period of 5 years ; and reclamation is in progress since February, 1950, only by means of drainage channels having outfall in Samora drain.

(*b*) *Nissang*—This experimental station of 205 acres was started quite recently on 16-3-1951, with Government approval, with a view to evolve the best reclamation technique. The area lies in village Nissang, and is recorded in Revenue papers for 167 acres as *Ghair mumkin* and for the remaining 38 acres as *banjar qadim*. The entire plot is *banjar* since times immemorial, and is infested with salts. A soil survey carried out in 1948-49 disclosed presence of the following :—

(i) Large percentage of salts, of which the predominants were sodium carbonates and bicarbonates which are rare in the West Punjab saline areas.

(ii) High pH values.

(iii) High clay and kankar contents.

(iv) Hard pan at some depth below the natural ground surface. So far only jungle clearance is in progress.

Rasul Hydel and Tube-well Project—It was the United Punjab's first big post-war scheme, to remedy water-logging in the Western Punjab, estimated to cost Rs. 10 crores and given a 'kick-off' on 17-11-46 when H.E. the Governor laid the foundation stone at Rasul in Gujart district of West Punjab. The Project must have been completed by now (in Pakistan), with a view to remedy, by means of tube-well pumping from the sub-soil, etc., the evil corollary of canal irrigation-water-logging, that is, the rapidly rising subsoil water-level in the Canal Colonies, in some places at the rate of 2 feet per year. The earliest reliable record is for 1900 when depth below ground-surface was 100 feet in the lands bounded by the Ravi and the Chenab and over 70 feet in the country between the Chenab and the Jhelum. After irrigation by the canals since 1887 to 1915, the maximum depth in the two places came to about 30 feet which rose temporarily after the monsoon to nearly 15 feet. The extent and seriousness of damage by water-logging in these colonies can be judged from the fact that while in 1932 the areas damaged by *sem* and *thur* were 26,000 and 300,000 acres respectively, to-day they are 34,000 and 14,00,000 acres ; and in addition there are large areas affected to a less extent. So great is the necessity of curing this malady, which is converting vast tracts of fertile land into saline lakes or salt-covered deserts, that the scheme was awarded priority number one in the province's post-war plans. The scheme is based on successful experience in U.S.A. In the Salt River Valley in Arizona, the water-table was brought down from 8 to 50 feet, and in parts of California as low as 200 feet by pumping.

In the West Punjab, it is hoped that the battery of 1,800 tube-wells, which will be sunk in the northern portion of the country bounded by the Jhelum and the Ravi, will begin to show beneficial results after three years of continuous pumping. To provide the necessary energy for the wells, hydro-electric power will be developed at Rasul where an 80 feet fall is available between the upper and lower Jhelum canals. The minimum firm power available at the site is about 8,000 kw. in the water. Wells will be located along the perennial canals with capacities of over 1,000 cusecs, where the spring level is within 10 feet of the surface. The water from the wells will be used to extend irrigation.

FOREST BOOMS*

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The cheapest method of transport of timber from the Forests to the markets below is by the agency of water. This method is accordingly largely made use of by state forest departments wherever streams and rivers for floating and rafting pass through forested Hills and Plains. The swan timber and logs are launched singly into the streams at a rate regulated according to the season of launching, condition and nature of the stream and the distance between launching and collecting depots, with the assistance of small contingent of floating labour. The timber so launched subsequently reaches the main river and is carried down to the plains below. As the river debouches from the hills, the water becomes shallow and its speed gets considerably reduced, the floating timbers are caught and diverted to the banks by an artificial obstacle termed a 'Boom' erected across the river. 'Boom' is a Dutch word meaning floating obstruction. It is essential to restrict the floating of the timber and to regulate its delivery and disposal at the boom site depending on the strength of the boom and the labour available. From here the timber is either tied into rafts and floated lower down or is sent out to the market by road or rail.

2. Almost any stream can be used for floating scantlings but logs are more exacting. Suitability of a stream for floating depends on the following factors :—

(i) the stream must be sufficiently wide and the water deep enough to allow free movement of the timber without its getting jammed against the banks and natural obstructions, etc. ;

(ii) the stream must be reasonably clear of natural obstructions such as bad rapids, submerged rocks and back waters ; and

(iii) the current should be moderate throughout the year or at least during a sufficiently long period, so as to enable successful floating. For floating purposes the best fall may be taken as 25 to 80 feet in a mile.

3. Special artificial channels made of sleepers are sometimes necessary to avoid sharp and tortuous rapids.

4. Season for floating timber depends upon the nature of the stream or river, its situation, the rainfall in its catchment area and the distance of the launching depots from the boom. In the case of small hill torrents the best time for launching the timber is the middle of the rainy season when there is sufficient water to enable easy floating. In the main river, the launching is usually done towards the end of the rainy season and the floating is so regulated that all timber reaches the boom at the latest by about March when the water-level begins to rise with the melting of the snow and endangers the life of the boom.

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* This small publication, though first of its kind on design and erection of booms, is the outcome of an official visit to the boom over the Beas river at Dehra Gopipur, District Kangra, East Punjab, at the special request from Shri Sunder Singh, I.F.S, Conservator of Forests, North Circle, East Punjab.

My thanks are due to Shri Y. G. Jadhav, Assistant Conservator of Forests, Amravari (M.P.) for his help in the preliminary calculations, to Shri R. D. Gupta, 1951-53 S.F.S. Course in the final checking of calculations and for drawing the stress diagram (as a class room exercise) and to Messrs. K. S. Sankhla, M. S. Solanki, H. P. Chothia, J. Mishra, A. F. Oswald, A. Tewari, G. P. Singh, K. G. Venkataram and P. C. Dass, 1951-53 S.F.S. Course, for copying and inking final sketches. I am grateful to artist Shri Raj Kumar Sharma of the Silviculture branch for lettering all the sketches.

N. J. MASANI.

5. The boom can be either of a permanent or temporary nature. Due to much fluctuation in the volume and speed of the current in the Indian streams permanent booms which demand extremely heavy capital expenditure are not feasible. Therefore, only seasonal temporary floating booms are erected. These booms are kept in position from about the beginning of October to about the middle of May, that is, during the period when the current and volume of water would be within reasonable limits.

6. The design of these booms varies widely on different streams according to the nature of the stream and the site. Primarily a boom consists of a chain of timber framework, so designed as to take the force of impact of floating timber, laid across the river at a suitable site with the help of steel wire rope and moored to stout posts securely embedded in the banks so that the boom itself floats in the stream in a loop between the anchorages.

7. A well designed boom from engineering point of view is not only economical in construction, but is also strong enough to resist the impact of floating timber. Thereby maintenance charges are rendered considerably low. Very often forest officers deviate from the constructional principles for want of a clear understanding of the theory and practice of boom designs and this results in frequent breakages and consequent heavy losses.

8. The selection of site for the erection of a boom is of very great importance, because a good site may considerably relieve the direct stress and strain on the boom, and thus indirectly influence its design. Of course when selecting the site other factors like stacking space, communication, nearness to the market, etc., should also be considered. For an ideal boom site : Fig. 1.

AN IDEAL SITE

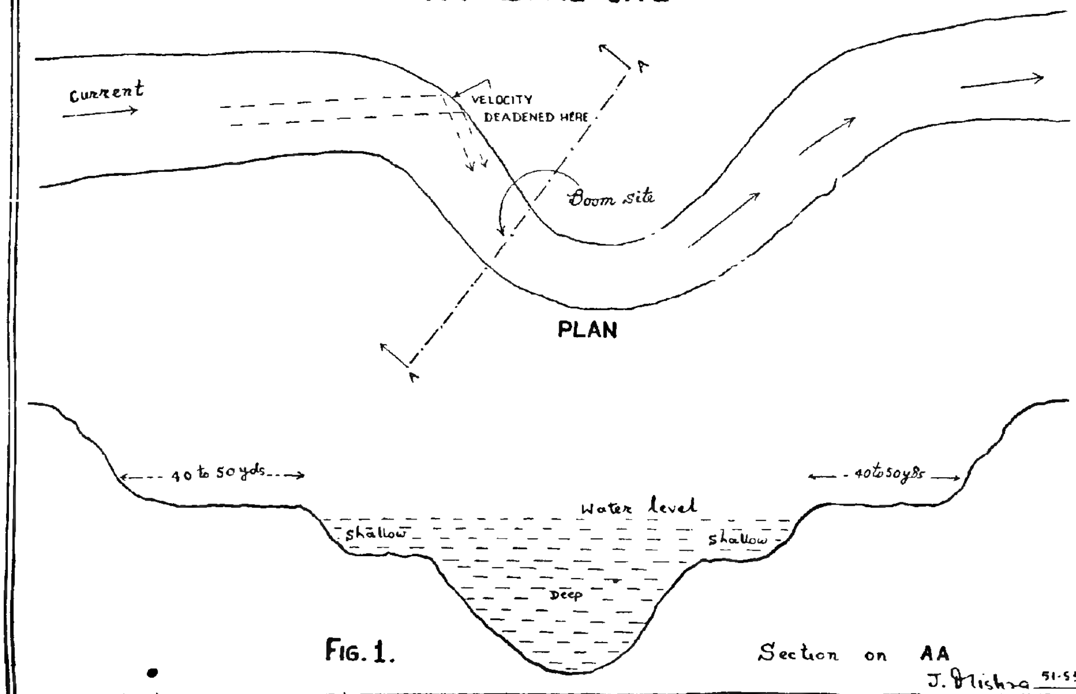


FIG. 1.

(1) the stream should be as narrow as possible so as to reduce the length of the boom as much as possible and thus minimize the danger of being broken by the impact of the timber ;

(2) the current of the stream must be slow ;

(3) shallow water should be available for the tying of rafts ;

(4) there must be sufficient high land available on the bank, or banks for stacking of timber at times of flood and for fixing the anchors for the main arm and the guy-ropes ; and

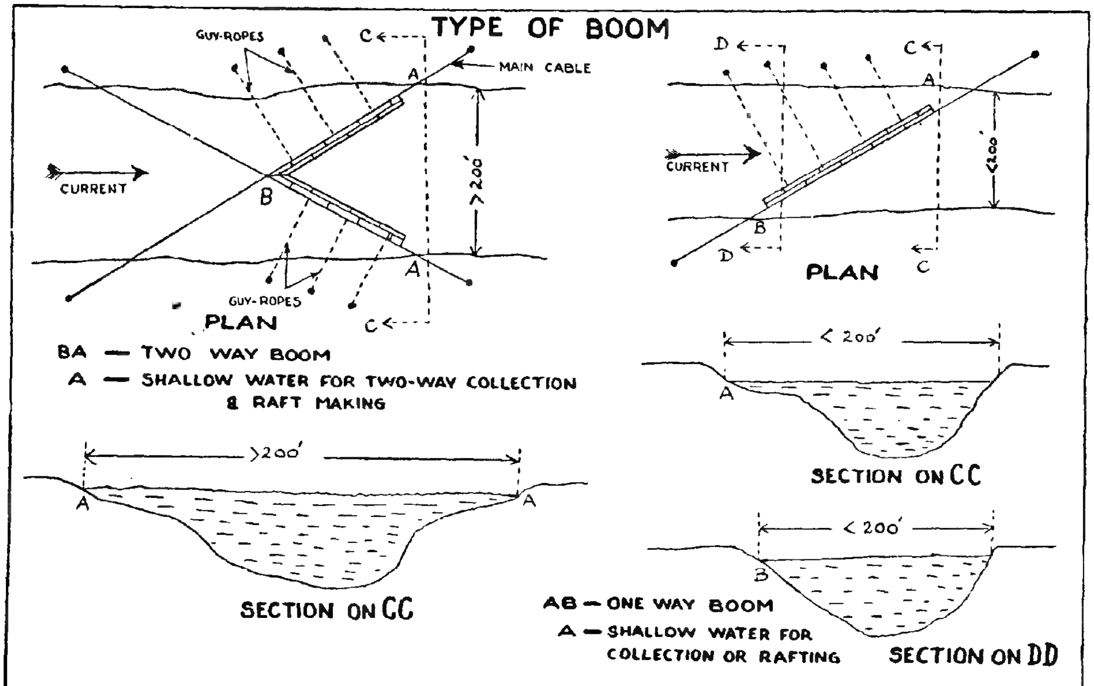
(5) if possible, the site should be a short distance below a sharp bend in the stream so that the timber may strike against the banks and lose their velocity before touching the boom.

9. *Design of Booms*—It would be easy for explaining and understanding if a concrete example is taken and the design of the boom explained step by step, so that forest officers, while designing booms for new sites, or improving existing ones, may find this publication of some help.

10. The design may be divided into : Figs. 2 and 3.

(*a*) Two-way boom*.

(*b*) One-way boom†.



A TWO-WAY BOOM

FIG. 2.

A ONE-WAY BOOM

FIG. 3.

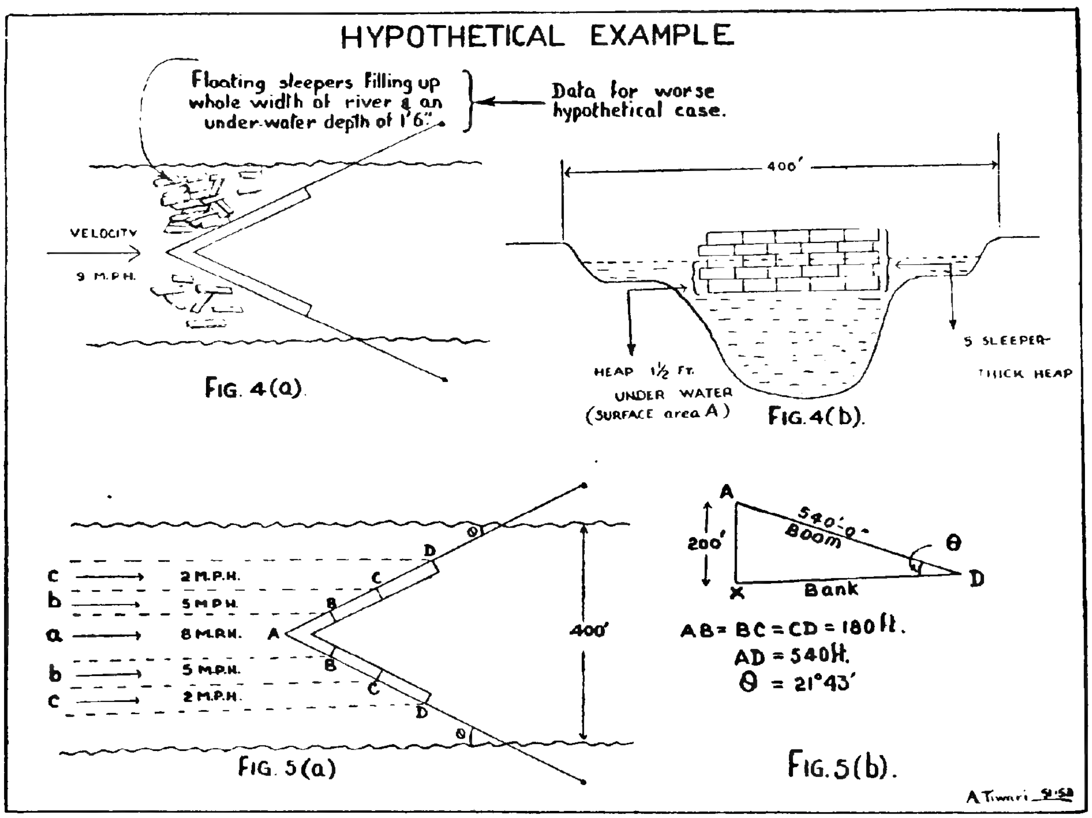
* Example of two-way boom is the boom at Dehra Gopipur, District Kangra, East Punjab.

† Example of one-way boom is the boom at Dak-Pathar over Jumna in U.P.

(*a*). If the site is such that (i) the river width is too much, (greater than 200 feet) and (ii) the section of river gap at the boom site is also such that shallow water exists on both banks, and/or (iii) facilities of road transport exists on both banks to send the collected timber to existing timber market, a two-way boom affords economy in lengths of guy-ropes, and facilitates two-way collection or raft making. Fig. 2.

(*b*) If the site is such that (i) river width is moderate (less than 200 feet), and/or (ii) section of river at site of boom such that its affords collection and raft making on one bank only, a one-way boom serves the purpose Fig. 3.

11. Let us consider a hypothetical example of a river 400 feet wide at the boom site with a velocity* at mid stream during floods of say, 9 m.p.h. and with the section of river at boom site being such as to afford a two-way working of the boom, and the timber to be caught by the boom being deodar (*Cedrus deodara*) sleepers. Fig. 4 (a).



12. The force acting on the boom surface will depend on the immersed surface area 'A' presented by the floating sleepers against the velocity of the current. It is on this important point of immersed surface area, that sections of guy-ropes and strength of boom-frames depend. If the drifting sleepers were to come piecemeal (i.e., as single sleeper), the depth of immersion of each sleeper will depend upon its buoyancy and thus the depth submerged could be calculated. No matter how wisely and well the launching of the sleepers is carried out upstream of the boom-site, with a view to making them arrive singly at the

* Velocity at Dehra Gopipur in February, as recorded by the author was only 1·5 m.p.h.

boom, they often arrive in heaps (i.e., blocks) with the result that the immersed area presented, to the current at the boom is many times more than what it would have been if they had arrived singly one at a time. Thus due to more weight of sleepers one above the other in a block, depth of sleepers under water increases, resulting in increased area under water. Fig. 4b.

13. If we take the height of tiers of sleepers one above the other to be say 5 sleepers thick – as the worst case during floods – then taking the weight of deodar sleeper as 35 lb. per cu. ft. and weight of water as 62·5 lb. per cu. ft. a piece of deodar 1 cu. ft. (i.e., $1' \times 1' \times 1'$) will submerge in water till the weight of water displaced equals that of the piece of deodar $= 35$ lb. Thus $\frac{35}{62 \cdot 5}$ part of 1 feet thick deodar will be under water. In our case of 5 sleeper thick heap, depth of heap under water will be $= \frac{2 \cdot 5}{1} \times \frac{35}{62 \cdot 5}$ ft. $= 1 \cdot 4$ ft. $= 1'\ 6''$ say.

[*Note* :—Here, each sleeper thickness is taken as 6″. Thus 5 sleeper thickness $= 5 \times 6 = 30'' = 2 \cdot 5'$ (Fig. 4b)].

Now as the velocity varies from 9 m.p.h. at mid-stream to zero m.p.h. at banks, let us divide the width of river such that

Sections 'a' has 8 m.p.h. average velocity
,, 'b' has 5 m.p.h. ,, ,,
and ,, 'c' has 2 m.p.h. ,, ,, (Fig. 5a).

14. The arrangement of the boom as seen from Fig. 5b is such as to give the max. length of each boom as 550 feet. Just as the river width was divided into three sections from the centre of river, let us design the boom in three sections on each side of the centre line of river. Thus $\theta = 21° 43'$ and AB = BC = CD = 180 feet.

$$\left[\begin{array}{l}\text{Because AD} = 540\ ;\ \text{AX} = 200' = \text{half the width of river.} \\ \text{Hence Sin}\ \theta = 200/540 = 0 \cdot 3703. \quad \therefore\ \theta = 21° 43'.\end{array}\right]$$

15. Now calculate the length of AB, BC, CD of the one side boom AD so that the boom-frames, guy-ropes and main ropes do not break or snap when water impinges on the boom at average velocities of 8, 5 and 2 m.p.h. on sections AB, BC and CD respectively.

Design of guy-ropes for section AB :—

River water impinges perpendicularly on an underwater surface of 1·5 feet depth and $\frac{200}{3}$ feet length when a timber block is created at boom site such that it fills up whole width of river to a depth of 1·5 feet underwater at the boom site Fig. 4.

$\therefore$ Volume of water impinging on the boom per second = surface area $\times$ average velocity $= \frac{1 \cdot 5}{1} \times \frac{200}{3} \times \frac{8 \times 5280}{60 \times 60}$

$= 1173 \cdot 3$ cu. ft. per second.

Momentum of this moving water is equal to mass of this water multiplied by its velocity.

$$\therefore \text{Momentum} = (1173 \cdot 3 \times 62 \cdot 5) \times \left(\frac{8 \times 5280}{60 \times 60} \right)$$
$$= 867,328 \text{ ft. lb./sec.}$$

16. This momentum of 867, 328 feet lb./sec. is being destroyed every second when timber is being obstructed in its passage by the boom, and thus this momentum is equal to the force exerted on the boom because force equals momentum destroyed per second. Therefore, in the case of AB, force is 867, 328 feet lb./sec^2.

Now $\frac{\text{force}}{\text{gravity acceleration}}$ = weight = W where 'W' is equivalent weight acting perpendicularly on the side of the boom AB and is supposed to be equally distributed on length AB of 180 feet

$\therefore$ W = $\frac{867,328}{32}$ = 27000 lb. ....(A).

If we allow 6 guy-ropes to be attached to side AB, and at right angles to the boom, then each guy-rope would take the weight equivalent to that coming on 30 feet of boom, because 180 feet is taken up by 6 ropes. Thus each of the six guy-ropes of section AB takes $\frac{27000}{6}$ = 4500 lb.

Now a steel wire rope of $2\frac{1}{4}''$ circumference will take – by thumb rule design – a load of 9 C^2 cwt. (where c = circumference of rope in inches). Thus 9 c^2 cwt.

= 9 × (2·25)^2 cwt.
= 9 × (2·25)^2 × 112 lb.
= 5103 lb.

$\therefore$ Use 6 guy-ropes each of 2·25 circumference S.W.R.

17. The following table adopted from 'Molesworth's Pocket Book of Engineering Formulæ' gives working strength and weight of iron and steel wire ropes of different sizes. This table confirms that a $2\frac{1}{4}''$ circumference S.W.R. will take a safe load of 5,107 lb.

Circumference of rope in inches	Iron wire		Steel wire	
	Weight per ft. run in lb.	Working strength in lb.	Weight per ft. run in lb.	Working strength in lb.
1	·14	650	·15	1,008
$1\frac{1}{4}$	·23	1,008	·23	1,568
$1\frac{1}{2}$	·33	1,456	·33	2,262
$1\frac{3}{4}$	·44	1,994	·45	3,001
2	·58	2,598	·59	4,032
$2\frac{1}{4}$	·73	3,293	·75	5,107
$2\frac{1}{2}$	·91	4,056	·93	6,294
$2\frac{3}{4}$	1·10	4,906	1·12	7,616
3	1·30	5,846	1·33	9,073
$3\frac{1}{4}$	1·53	6,854	1·57	10,640
$3\frac{1}{2}$	1·78	7,952	1·82	12,342
$3\frac{3}{4}$	2·04	9,139	2·09	14,179
4	2·32	10,394	2·37	16,128
$4\frac{1}{4}$	2·62	11,738	2·68	18,211
$4\frac{1}{2}$	2·94	13,149	3·00	20,406
$4\frac{3}{4}$	3·27	14,650	3·34	22,736
5	3·62	16,240	3·70	25,200

18. The above table takes into account merely the size of the rope. Now the strength of a wire rope depends on three factors, viz.: (1) Size of rope, (2) Breaking stress of the wire and (3) 'Construction' of rope. By 'Construction' is meant, the number of strands as well as number of wires in each of the strand irrespective of the size of rope or gauge of wire used. Thus a 6/7 rope means six strands each of seven wires. Thus for the same size (i.e., circumference) of a wire rope, a variation of either of the breaking stress of wire or 'construction' of wire rope may greatly alter the safe load for the rope. Thus the above table which gives only the size of rope and their safe working loads should be taken as very approximate. Thus, to choose, along with a proper size : the 'construction' of the rope as also the breaking stress of wire used in the rope, refer the following alignment chart in Fig. 6, which is self-explanatory. Thus we see from table as well as the chart that to sustain a safe load of 4,500 lb., we should use a steel wire rope of 2·25″ circumference (see table), and with a 'construction' of wire 6/24 and of breaking stress of wire 85 tons per sq. in. (see chart in Fig. 6). To indent for the S.W.R. for section AB, write as follows :—

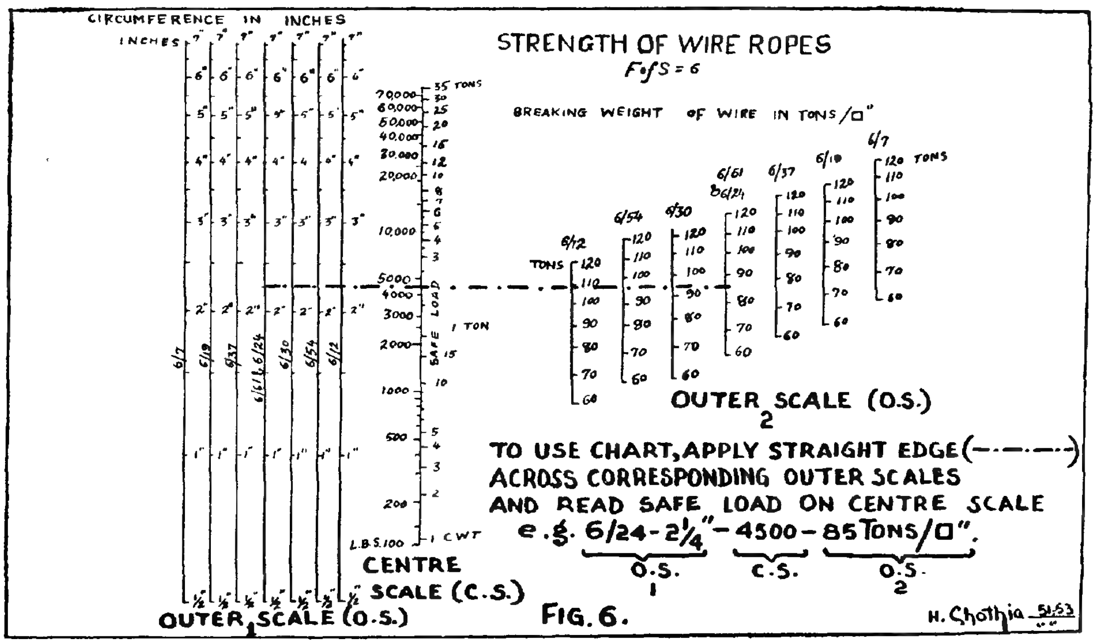


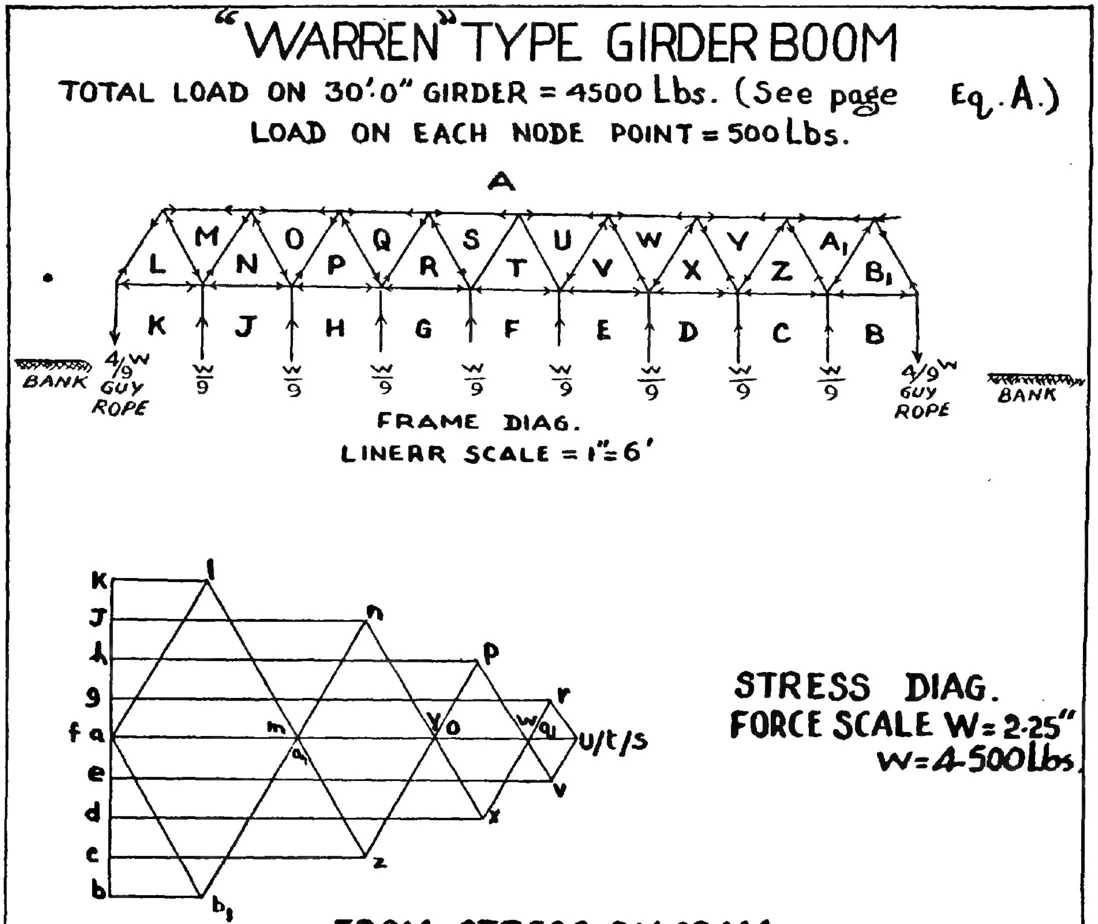
FIG. 6.

Steel wire rope 6/24—$2\frac{1}{4}$ inch—85 tons/sq. in. of length 'x' feet.

Design of boom frame for section AB of the boom AD.

As AB = 180 feet (Fig. 5) divide it such that each frame is easily handled and erected at site, without undue labour and extra erection machinery. If we keep length of frame 10 feet then between three frame lengths, i.e., 30 feet comes two guy-ropes, one on each end of 30 feet. Thus the three frames (each of 10 feet length) make a girder of 30 feet between two supports (each support being a guy-rope, taking $\frac{4,500}{2}$ lb.). Weight coming on this girder of 30 feet length is $\frac{27000}{180} \times \frac{30}{1}$, i.e., = 4,500 lb. Let us design this girder as a

timber girder of deodar (*Cedrus deodara*) of Warren type as shown in Fig. 7. From the stress diagram* we find that :—



FROM STRESS DIAGRAM.

Member A.S. carries Max. Tensile Force of 5800 Lbs. in the top chord.

Member F.T. carries Max. compressive Force of 5800 Lbs. in the bottom chord.

Member A.B1 carries Max. Tensile Force of 3300 Lbs. in the Diagonals.

Member A1B1 carries Max. Compressive Force of 3300 Lbs. in the Diagonals.

FIG. 7.

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* For drawing a stress diagram for any frame structure the reader is invited to refer to F.R.I. publication by the same author on "Simple Calculations in the Design of Forest Bridges of stock spans of 15, 20, 30 and 40 feet, Part V, page 141-E, available from P.L.O., F.R.I. and Colleges, Dehra Dun, U.P. or to refer to article in *Indian Forester* of June, 1951, Vol. 77, No. 6.

(i) Max. tensile force in top chord (down-stream side chord) is in member AS and = 5,800 lb.

(ii) Max. compressive force in bottom chord (up-stream side chord) is in member ET and = 5,800 lb.

(iii) Max. tensile force in diagonals is in member AB, and = 3,300 lb.

(iv) Max. compressive force in diagonals is in member AB and = 3,300 lb.

19. If we design top chord, bottom chord and diagonals of such sizes as to sustain the max. force in their respective categories, we will have a safe design of uniform sizes which although a bit wasteful in timber, will compensate in its making charges and also avoid the risk of wrong placement of members by forest mistry or carpenter.

Design of Top Chord :—Fig. 8.

Tensile force 'T' = $f_t \times a$

where f_t = tensile stress for deodar = 1,000* lb./sq. in. for wet locaters.

a = net area of section.

T = 5,800 lb. as found from stress diag. Fig. 7.

$\therefore$ 5,800 = 1,000 $\times$ a

$\therefore$ a = 5·8 sq. inches.

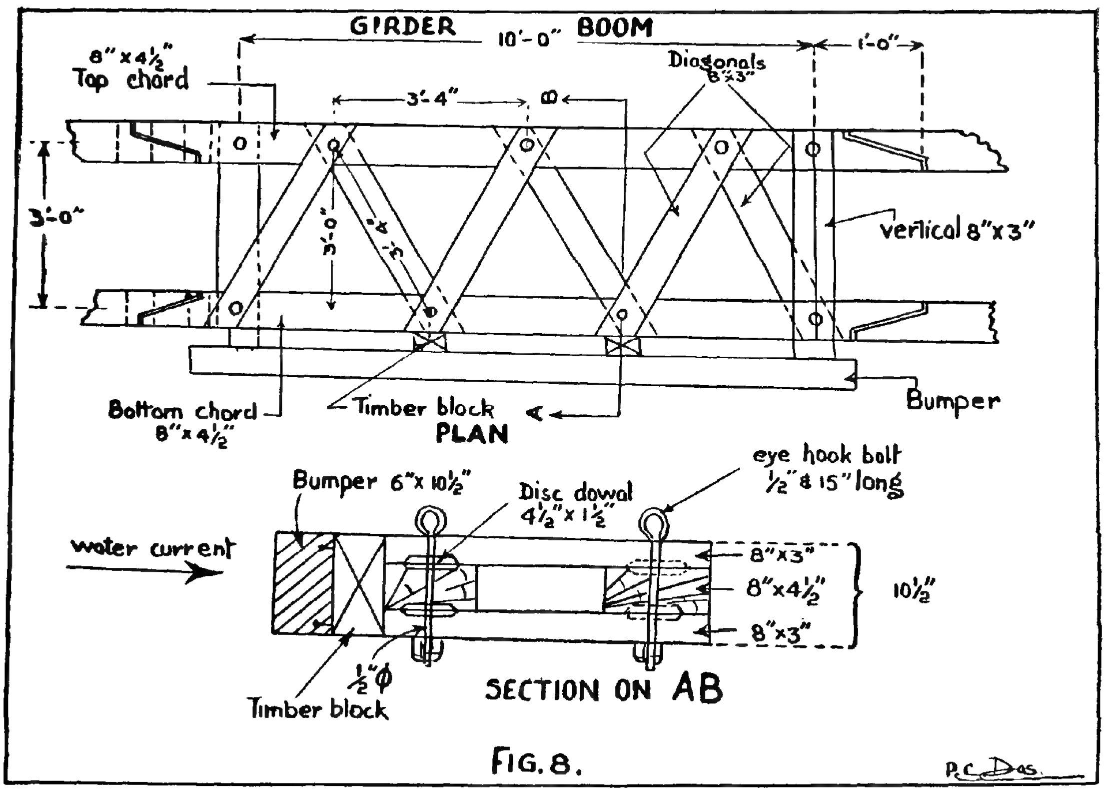


FIG. 8.

Now top chord of each boom frame will be 10 feet long and at places where diagonals meet the top chord, they will be joined by means of one timber disc dowel of diameter 4½" thick. If we take an overall section of top chord as 8" × 4½", then deducting for disc dowel hole = 4½" × { 2 × (½ × $\frac{3}{2}$) }" we have a net section of top chord = 3½" × 3" = 10·5

* Safe working stresses for deodar is taken from *Indian Forest Records* "Utilization", Vol. 4, No. 1, F.R.I. publication.

sq. in. Thus net area provided is greater than net area required. Therefore, the section of top chord $8'' \times 4\frac{1}{2}''$ is safe.

20. Again a timber disc dowel* made of *babul* (*Acacia arabica*) refer Appendix I, and of size $4\frac{1}{2}''$ diameter and $1\frac{1}{2}''$ thick will take a safe working stress against shear of 5,000 lb. The max. shear force at the joint between diagonal and top chord trying to shear away the disc dowel is 5,800 lb. Two disc dowels take up this shear and are, therefore safe, each taking 2,900 lb., whereas each of them can sustain 5,000 lb.

Design of Bottom Chord :—Fig. 8.

Max. compressive force C = 5,800 lb.

Assume a section of chord $8'' \times 4\frac{1}{2}''$ overall.

Deducting for disc dowel hole, net area of chord section $= 3\frac{1}{2}'' \times 3'' = 10 \cdot 5$ sq. in. Length of each chord in compression equals $3'\ 4'' = 40''$.

$\therefore$ Slenderness ratio $= \frac{l}{d} = \frac{40}{3} = 13 \cdot 3$, where d = least dimension of chord net section. Since slenderness ratio is less than 15, design bottom chord as short column†

$\therefore$ $C = f_c \times a$. where C = Compressive force in member = 5,800 lb.

$\therefore$ $5{,}800 = 800 \times a$. f_c = safe compressive stress for deodar parallel to grain = 800 lb. per sq. in. for wet location.

$\therefore$ $a = 7 \cdot 25$ sq. in. 'a' = net area.

21. Thus with an overall section of $8'' \times 4\frac{1}{2}''$, giving a net section of $3\frac{1}{2}'' \times 3''$ (i.e., $10 \cdot 5$ sq. in.) after deducting for disc dowel joints, the section is safe.

Design of Diagonals carrying Tensile Forces :

Max. Tensile Force = 3,300 lb. = T.

$\therefore$ $T = f_t \times a$.

$\therefore$ $3{,}300 = 1{,}000 \times a$. $\quad\therefore$ $a = 3 \cdot 3$ sq. in. net.

One member holds one disc dowel of diameter $4\frac{1}{2}''$ and thickness $\frac{3}{4}''$.

$\therefore$ Taking an overall section of $8'' \times 3''$ we have net area deducting for disc dowel hole equal to $3\frac{1}{2}'' \times 2\frac{1}{4}'' = 7 \cdot 9$ sq. in.

$\therefore$ Section is very safe.

Design of Diagonals carrying Compressive Forces :—

Max. compressive force = C = 3,300 lb.

Assuming an overall section of $8'' \times 3''$ and deducting for one disc dowel we have a net section of $3\frac{1}{2}'' \times 2\frac{1}{4}''$ (i.e., $a = 7 \cdot 90''$). Slenderness ratio $= \frac{l}{d} = \frac{40}{1} \div \frac{9}{4} = 18$ approx. ; since $\frac{l}{d} > 15$, we design this member as long column.

$$\therefore\ f_p = f_c\left(1 - \frac{l}{60d}\right) \text{ where } \begin{array}{l} f_p = \text{permissible stress} \\ f_c = 800 \text{ lb. permissible stress} \end{array}$$

$$\therefore\ f_p = 800\left(1 - \frac{40 \times 4}{60 \times 9}\right) \quad \begin{array}{l} l = 40'' \\ d = 2\frac{1}{4}'' \end{array}$$

$$= 573 \text{ lb./sq. in.}$$

---

* For design of disc dowel and work carried out at F.R.I. read *Indian Forest Leaflet* No. 31 – Wood Disc Dowel Joints in Timber Framed Structures.

† Design of all types of timber columns is dealt with step by step in the author's publication on "Simple Calculation in the Design of Forest Bridges", Part IV, F.R.I. publication.

$\therefore$ $C = f_p \times a$

$\therefore$ $3{,}300 = 573 \times a$ $\quad\therefore$ $a = 5 \cdot 7$ sq. in. net area required

But net area provided $= 7 \cdot 8$ sq. in.

$\therefore$ Section is safe.

Design of disc dowel :—Disc dowel of *babul* at the joints in Fig. 8 is subjected to max. shearing of 3,300 lb. as seen from Fig. 7, at mid section and an equal compression along the grain at the bearing surface*. Design disc dowel for equal strength against both shearing and bearing, i.e., $\frac{\pi d^2}{4} \times s =$ Max. Force

Again $\frac{d}{1} \times \frac{t}{2} \times c =$ Max. Force.

Where s = safe working stress in shear along grain
= 315 lb./□ in. for *babul*
d = diameter of dowel = $4\frac{1}{2}''$
t = thickness of dowel
c = safe compressive stress along grain
= 800 lb./sq. in. for deodar*

$$3{,}300 = d \times \frac{t}{2} \times c$$

$$3{,}300 = 4 \cdot 5 \times \frac{t}{2} \times 800$$

$$\therefore \quad t = 1 \cdot 8 \text{ inches.}$$

$\therefore$ Using one *babul* disc dowel of $4\frac{1}{2}''$ diameter and $1 \cdot 75''$ thickness it will resist a shear force of 5,000 lb. Thus at every diagonal, the joint is with one disc dowel and is safe. Max. shearing at top and bottom chords is 5,800 ; and this is resisted by two disc dowels (see Fig. 8) and therefore is safe.

22. The assembly of one boom frame section of 10 feet length is as shown in Figs. 8 and 9. This light economical but strong boom frame will float with about 5 to 7 inches of its depth submerged under water due to its buoyancy. This 10 feet length of frame† takes only about 10 cu. ft., requires 10 numbers of $\frac{1}{2}''$ diameter bolts each $15''$ long and 16 numbers of *babul* disc dowel of $4\frac{1}{2}'' \times 1\frac{3}{4}''$ each. To build each frame carpentry including iron mongering charges will be approx. Rs. 20. A detachable deodar sleeper $12' \times 12'' \times 6''$ is attached to each frame and acts as a bumper to receive shock and wear and tear. Any damage that occurs to the boom is thus localized to a particular bumper only, which could be easily replaced (without damaging the main boom frame). The bumper is attached to the frame by what is commonly called "Key hole and screw attachment" (Fig. 8).

23. Design of guy-ropes in section BC of Boom AD :—(Fig. 5).

Design follows the same principle as in the design of guy-ropes in section AB of the Boom AD, with the only change that average velocity in this sector 'b' is 5 m.p.h. As noticed before, weight 'W' coming on the boom varies as the squares of the velocity. Therefore, for section BC, $W = \frac{5^2}{8^2} \times \frac{27{,}000}{1} = 10{,}530$ lb. ......(B). If we use the same type of S.W.R. as was used previously, i.e., S.W.R. 6/24 — $2\frac{1}{4}$ inch — 85 tons per sq. in., taking 4,500 lb. working load, then the number of guy-ropes required to keep 180 feet of section BC of boom AD in position without failure are $4{,}500 \times X = 10{,}530$ $\quad\therefore X = \frac{10{,}530}{4{,}500} = 3$ nos.

* Here *babul* disc dowel bears against deodar member which has only 800 lb./sq. in. as compressive stress parallel to grain as against 1,600 lb./sq. in., for *babul*. Therefore, take the lower value for safe design against bearing.

† 10 feet length of frame at Dak-Pathar Boom utilizes 21 cu. ft. of timber, carpentry charges are Rs. 40 per frame excluding iron-mongering.

∴ Use 3 guy-ropes over a length of 180 ft. of S.W.R. 6/24 — $2\frac{1}{4}$ in. — 85 tons per sq. in. Therefore, distance between any two guy-ropes in section BC will be 90 feet.

24. Design of boom frames for section BC :—

Weight carried by a 90 feet Warren girder between two guy-ropes $= \frac{10,530}{180} \times \frac{90}{1}$ $= 5,265$ lb. Thus for section BC, we shall have nine girder frames, each of 10 feet length joined together with thin wire ropes. Following the same method as in design of girder frame for section AB, we find that the same size boom-frames are very safe.

25. Design of guy-ropes in section CD of boom AD :—

If we use the same type of steel wire ropes, i.e., S.W.R. 6/24 — $2\frac{1}{4}$ — 85 tons per sq. in., taking 4,500 lb. working load, then the number of guy-ropes required to keep 180 feet of section CD of boom AD in position without failure are $4,500 \times X = 1,688$ where 1,688 lb. weight coming on CD is derived from $\frac{2^2}{8^2} \times \frac{27,000}{1} = 1,688$ lb., velocity over section CD = 2 m.p.h. Therefore, $X = \frac{1,688}{4,500} =$ less than one. But use two guy-ropes of S.W.R. 6/24 — $2\frac{1}{4}$ inch — 85 tons per sq. inch for practical reasons of keeping the section CD in position.

Design of boom frames for section CD :—

Same size girder frames as used for section AB, are very safe.

26. Method of launching the boom AD in position :—

Holes are bored in the spliced ends of girder sections, and when one section of 10 ft. is fitted to another section of 10 feet length, thin wire ropes are passed through these holes (Figs. 8 and 9) and round the top and bottom chords of girders so as to prevent several sections of which the whole boom is made up of, from opening out. At a time three to four girder sections are joined by thin wires, towed in position with help of their guy-ropes, where the boom is to be placed. Two main wire ropes of the boom (design of which will be discussed later) are now passed through each of the eyebolts of the girder sections the one end of each main rope being securely fastened to fixed anchorages on one bank. When all girder sections are in position, the other end of each main rope is tied to the last girder section. These two main ropes keep the length of boom fixed at the place desired, while the guy-ropes play the part of keeping the boom length at desired angle with the bank and also take up all the strains coming on the boom.

27. A line of planking 1′ 6″ wide and supported on diagonals of 'Warren' girder are nailed along the centre of girder framework to allow a few men (not more than one per section of 10 feet length) at a time to walk up and down the boom and prevent sleepers from striking end on against the bumper, provided in front of girder, when choke-a-block occurs.

28. Design of main cables and their fixed anchorages :—

The stronger the current of the stream, the greater is the strain (tension) on the guy-ropes and greater is the weight (force) impinged on the side of the boom. A very negligible part of the bending strain of the girder boom comes on the main cables, due to slight hinged action created at the joints of every boom-frame section of 10 feet length. Main cables are also tensioned due to the frictional force of the component part of the force of water, acting parallel to the sides of the boom-frames. These two strains are very small, and the use of two main cables of S.W.R. 6/24—$2\frac{1}{4}''$—85 tons per sq. inch is more than sufficient to take the strains and also keep the whole boom AD in position by fixed anchorages at the up-stream end of main cables.

29. Design of Bumper :—(Figs. 8 and 9).

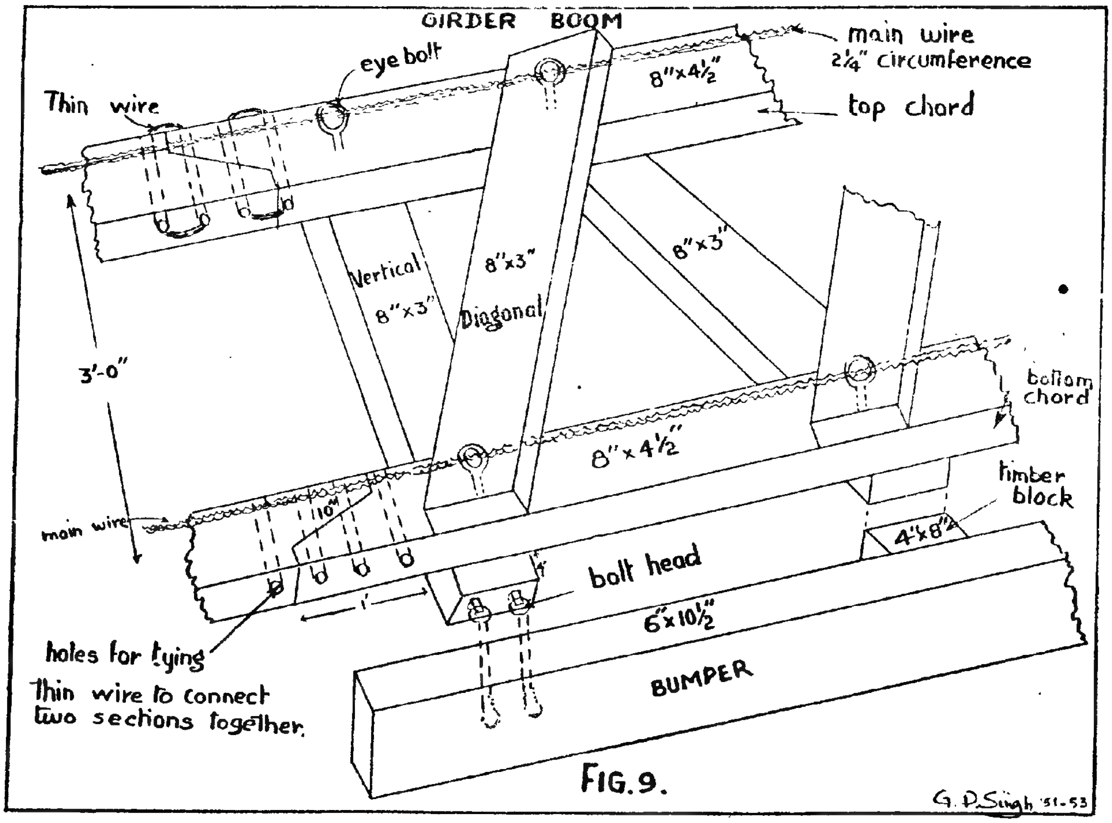


FIG. 9.

Bending moment coming on each bumper of about 12 feet length is due to the force of impact of drifting sleepers. Design of bumper section for boom section AB which carries the greatest impact will be provided for all bumpers over the whole boom.

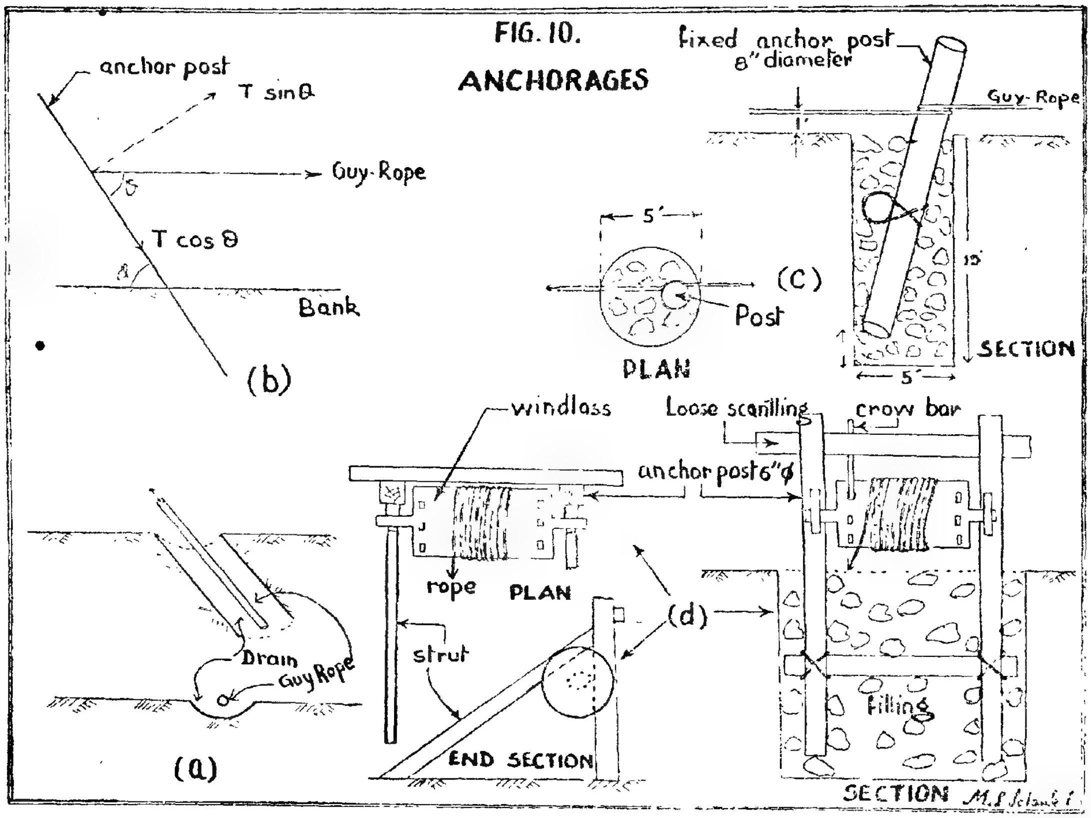
30. We had seen that uniformly distributed load carried by 30 ft. length of boom in section AB was 4,500 lb. Therefore, 12 ft. length will take $W = \frac{4,500}{30} \times \frac{12}{1} = 1,800$ lb.

B.M. due to uniformly distributed load of 1,800 lb. $= \frac{Wl}{8} = \frac{1,800 \times (12 \times 12)}{8}$ in. lb. Therefore, B.M. $= 32,400$ in. lb. Now moment of resistance of a bumper section of $10\frac{1}{2}'' \times 6''$ is M.R. $= f \times z = 1,000 \times \frac{b \times d^2}{6} = 1,000 \times \frac{10 \cdot 5 \times (6)^2}{6} = 63,000$ in lb. $\therefore$ M.R. $>$ B.M.

$\therefore$ use each bumper of 12 ft. length and section $10\frac{1}{2}'' \times 6''$.

Guy-ropes and their anchorages :—Fig. 10.

(1) Whole length of each guy-rope in between its end must be free of ground contact so as to avoid wear of guy-ropes due to friction, when boom moves to and fro and also up and down due to current, waves, rise and fall of river water, etc., Fig. 10(*a*).



(2) Direction of guy-rope end with the boom must be at right angles to give minimum of force in guy-rope.

(3) Anchorage post must be at an inclination away from the water (i.e., towards bank side) so as to reduce force (T sin θ) of bending on the anchor post, and simultaneously the other component (T cos θ) force helping the anchor post from lifting away due to rise and fall of river water. Fig. 10(*b*).

(4) Anchor post must be of sufficient section to resist breakage by bending or failure by shearing.

(5) Guy-ropes should be tied to anchorage post as near to the ground surface as practicable to avoid cantilever action on post Fig. 10(*b*).

(6) Anchorage post should be well embedded in the ground so as not to be lifted up due to upward lift of the boom in rising river level during floods Fig. 10(*c*).

31. Design of anchor post for guy-ropes of section AB of the boom AD :—

(*a*) Guy-rope fixed to one anchor post :

Force on each guy-rope = 4,500 − 500 = 4,000 lb. If guy-rope is tied 1 foot above the ground surface on the anchor post, bending moment on the post at G.L. = 4,000 × 12″ = 48·000 in lb. Now moment of resistance of post = f × z. Taking a round post of d″ diameter we have M.R. = 1,250 × 0·0982d³ ∴ 48,000 = 122·75 d³ ∴ d = 8″ approx. Now for testing this post of 8″ diameter against a shear force of 4,000 lb. we have area of section × shear stress of deodar, must be equal to 4,000 lb.

$\therefore \frac{\pi d^2}{4} \times 100 = 4{,}000 \quad \therefore d = 7''$ approx.

$\therefore$ 8″ diameter post is sufficient to resist shear as well as bending

$\therefore$ use an anchor post of 8″ diameter and 12 feet long so that 9 feet length is under ground. Fig. 10(c) and three feet is above ground.

(*b*) Guy-rope fixed to *windlass* :

Here instead of one post two anchor post will be required to carry the windlass (made of sal, etc.). Therefore, 6″ diameter two post will be sufficient. The arrangement will be as shown in Fig. 10(*d*).

These anchor posts should be sunk at least 8 to 10 feet into the ground and made to slant towards the bank making angle θ Fig. 10(*b*) with the horizontal. Pit is dug 12 feet deep and 5 feet (for single post) to 7 feet (for double post with windlass) in diameter. With the anchor posts fixed in position in the pit, the rest of the pit is filled with stone and earth (clayey loam) tightly packed Fig. 10(*d*).

32. In order that the inclination of the boom with the current could be changed by tightening or loosening the guy-ropes as may be necessary single anchor post at each guy-rope is replaced by a windlass frame and drum with holes in them at ends to engage a crow-bar for keeping the drum at a desired position Fig. 10(*d*).

33. Design of anchorages for sections BC and CD of boom AD :—

Same as that for section AB, since forces on guy-ropes in BC and CD are less than those in section AB. Therefore, design is safe.

Conclusion—Launching should be so arranged that a great number of sleepers or logs do not arrive at the boom site at the same time in a block more than 2′ 6″ high because this limited depth, within which this boom is safe against breaking and guy-ropes strong against snapping. In spite of all precautions, if at any time it is observed that the block created throughout the width of river is more than 2′ 6″ high, boom should be eased by loosening the guy-ropes and allowing the congestion of sleepers to go downstream, thus easing the over-strain on the boom whereby it will not snap.

34. Many a existing boom, in India, requires that one or the other of the points relating to the design and erection mentioned above, should be looked into, in order to make it work efficiently and economically. A key plan of the boom site shows an ideal arrangement and design as discussed above (Figs. 11 and 13). It is almost impossible to find such an ideal site fulfilling all the above conditions. However, it is for you to discriminate those points only, on which you think greater stress should be laid.

Care and maintenance of steel wire ropes—Very little supervision is maintained by us over this important point. The path of guy-ropes and main cables should be cleared of all obstructions including stacking of sleepers* collected at boom site. All ropes should be lubricated once before use, and once when they are stored up. The object of lubrication is both, to preserve the hemp core and wires against the effects of exposure to weather, and to eliminate internal wear caused by the wires rubbing against one another. It is not enough to grease the outside of the rope only, as is commonly practised ; the lubricant must be got into the interior of the rope, where the hemp core will retain it and so prevent internal friction. The following mixture can be used melted and applied hot as a lubricant :—

6 parts tar : 2 parts linseed oil : 2 parts tallow.

* During the author's inspection visit to Dak-Pathar boom over 50% of the guy-ropes were concealed by timber stacked over them.

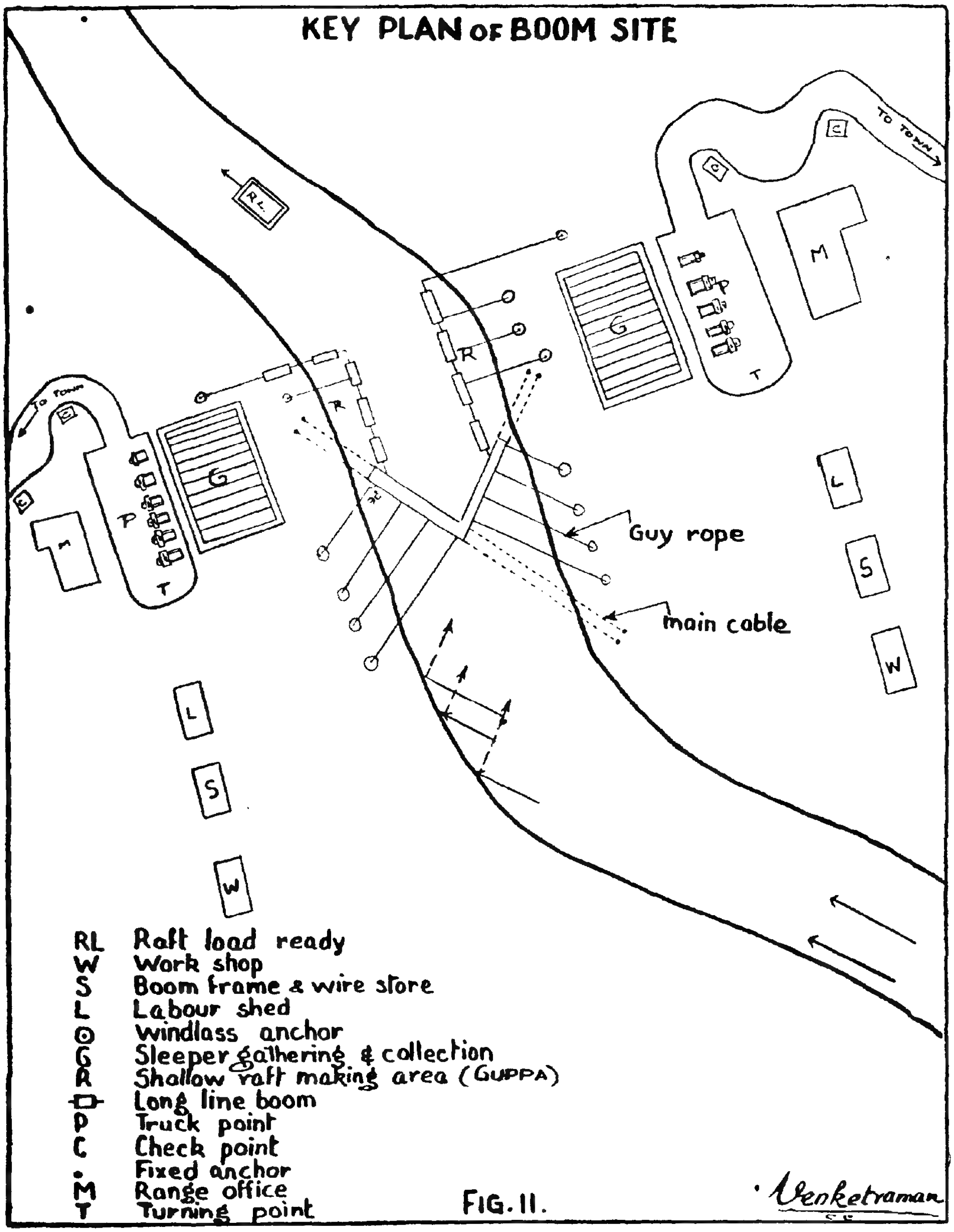


FIG. 11.

Ends of guy-rope, over windlass and drum, should go round a larger size of drum. Where windlass are not used, anchor post should be round rather than rectangular (as is often the

case, e.g., Booms at Dehra Gopipur in East Punjab and Dak-Pathar at Kalsi in U.P.) so that guy-ropes could be tied, without injury to the strands of rope. Roundness of this anchor post where the guy-rope end is tied should not be less than four times the circumference of the rope. In our case, the post will not be less than $4 \times \frac{9}{4} = 9''$ circumference. Where windlass is used circumference of drum should not be less than six times circumference of rope. In our case of $2\frac{1}{4}''$ circumference of S.W.R., drum circumference should not be less than $6 \times \frac{9}{4} = 14$ inches.

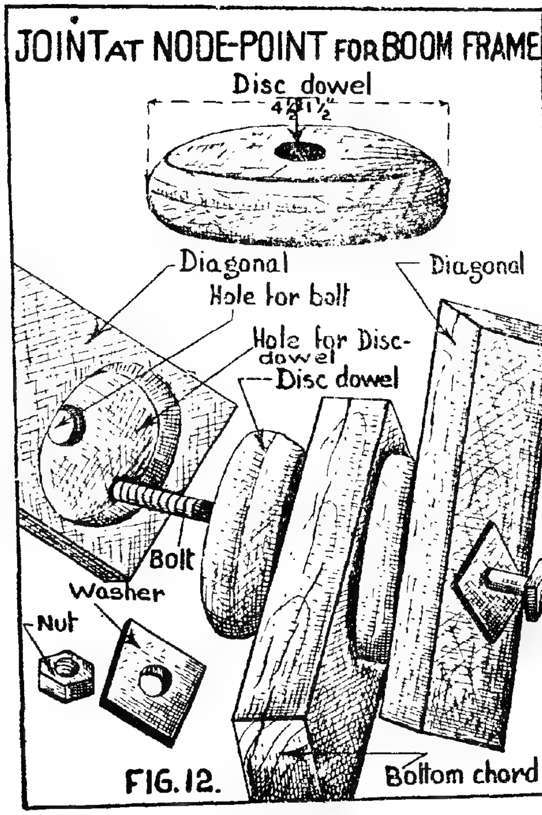


FIG. 12.

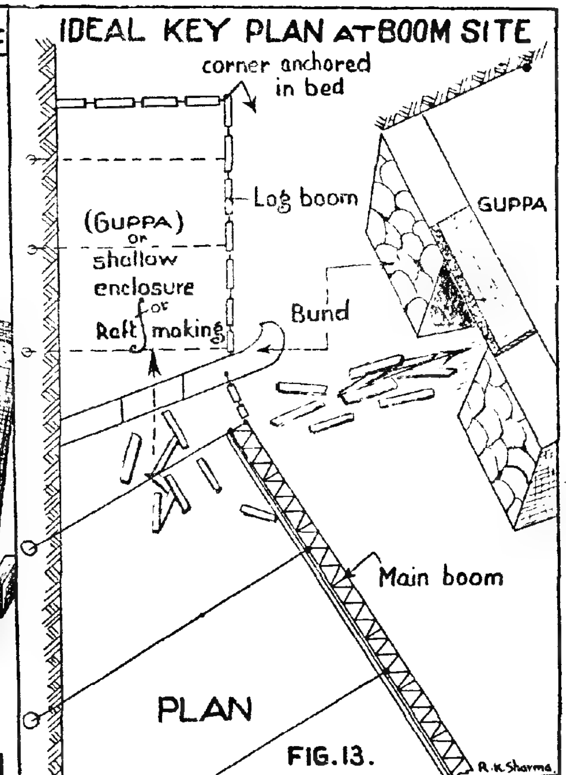


FIG. 13.

35. Working site for collection and for raft making :—

Obstructing the drifting sleepers or logs at boom is not the end all of the object of a boom erection. Next phase and an important phase at that is to sort out and collect the different species and store them on banks and/or make them into rafts. This requires 'shallow-working' conditions on both banks (preferably) or on any bank depending upon the site as mentioned previously. For this purpose a sort of a 'shallow water tank' where labourers can work with ease, and where the trapped sleepers at the boom could be temporarily shifted, in the river itself is to be constructed. This shallow water tank (called *guppa* in U.P.) could be effectively created by encircling the shallow water area at the end of boom on the down-stream side with a 'log-line' or single - sleeper 'boom'. This shallow water tank thus consists of two sides made of log line boom, third side being a drystone bund (with an opening to allow sleepers from boom area to enter the shallow tank area) with the existing river bank making the fourth side (Fig. 13).

PLATE I

1

A TYPICAL CHOKE-A-BLOCK OF SLEEPERS AT *DAKPATHAR* BOOM.

2

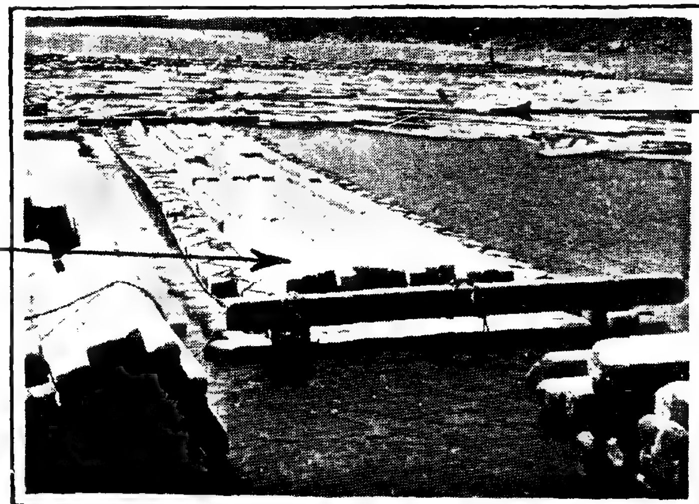
FIXED TYPE STEEL ANCHORAGE IN ROCKY RIVER BANK.

(Photos by H. Chothia 51-53.)

PLATE II
(Photo by K.S. Sankhala)
51-53.

3

4



5

SLEEPERS ENTERING SLUICE GATE IN THE BUND.

RAFT READY FOR ONWARD VOYAGE.

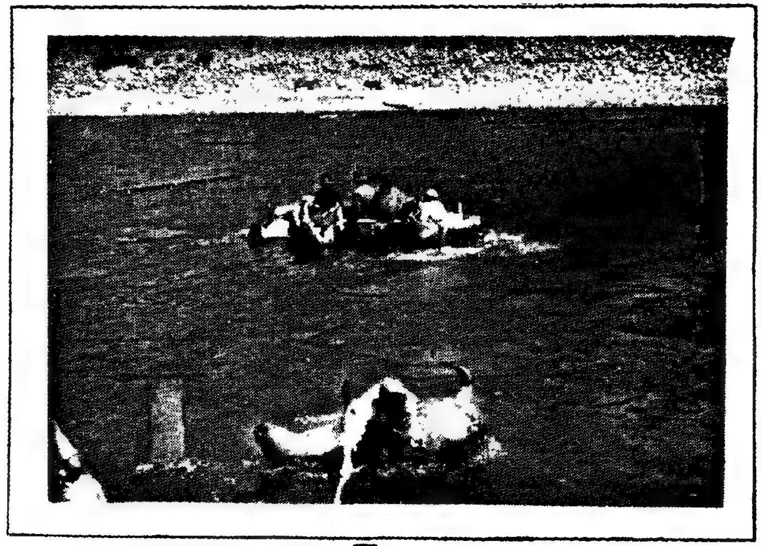
PORTION OF 'GUPPA' ENCLOSURE WITH A RAFT READY. MAIN BUND IS IN BACK-GROUND.

SOME MORE SLEEPERS AWAITING MAKING INTO RAFTS.

PLATE III

6

MALLAHS WITH THEIR SARNAIS ON BACK.



7

SARNAIS IN ACTION.

(Photos by M.S.Solanki. 51-53.)

Section of the band at base and top should be sufficient to resist pressure of water. Thumb-rule application for bund section is : (Fig. 13). For dry stone bund :

(*a*) Thickness at base of bund with river bed = $0 \cdot 5\ H_E$

(*b*) Half of (*a*) gives width at top of bund

(*c*) $1\frac{1}{2}$ of (*a*) gives width at foundation bed
where H_E = Height of water in feet impounded (H) + foundation depth.

$$\text{And foundation depth} = \left(\frac{H}{10} + 1\right) \text{ feet.}$$

Note.—Due to shallow water conditions, velocity of water at side of bund is practically negligible.

36. Example for a dry stone bund design :—

Data—Dry stone bund extends into the river for 50 feet and impounds water of height = 5 feet. Velocity over 50 feet length is 1 ft./sec.

Design :

$$\text{Foundation depth below river bed} = \left(\frac{H}{10} + 1\right) \text{feet} = \left(\frac{5}{10} + 1\right) \text{feet} = 1\tfrac{1}{2} \text{ feet.}$$

Equivalent height $H_E = H +$ foundation depth $= 5 + 1\frac{1}{2} = 6\frac{1}{2}$ feet.

$\therefore$ (*a*) Thickness at base $= 0 \cdot 5\ H_E = 0 \cdot 5 \times 6 \cdot 5 = 3 \cdot 25$ ft.

(*b*) Width at top of bund $= 1 \cdot 62$ ft.

(*c*) Width at foundation bed $= 4 \cdot 86$ ft.

37. Some recent photographs of the working of the boom at Dak-Pathar on Jumna in U.P.

PLATE I

Photo 1, shows a typical 'choke-a-block' occurring at the boom site. Labour is seen walking on the platform of the main boom, to break the block and clear the timber safely into the *guppa* before the damage is done to cables, guy-ropes, or boom-frames. The main boom is of old rectangular design, wasteful in timber, steel, carpentry joints, labour, etc.

Photo 2, shows fixed type of main cable anchorage of iron rod embedded in rocky bank strata. The rod is in the form of a bent staple, and should be from $1\frac{1}{2}''$ to $2''$ diameter, sunk 18″ into the rock and leaded into it permanently.

PLATE II

Photo 3, shows sluice gate in the main bund forming one side of *guppa*. Sluice opening is indicated in the photo by the stick held in the hand of second person from right. On the left is shown a labourer helping to get the sleepers into the *guppa* with the help of a special hooked rod.

Photo 4, looking up-stream, shows in the background, the main bund of *guppa* with its sluice gate on left, bridged over by sleeper. In front is seen a part of *guppa* with a raft ready for sailing. On right top corner is seen the 'log-boom' or *line-dori*, forming another side of *guppa* enclosure.

Photo 5, shows a raft made ready for its onward voyage down-stream. In the background is seen sleepers collected in the *guppa* enclosure, ready for raft making.

PLATE III

Photo 6, men who work in water in connection with boom erection and also during working season, use inflated bullock or goat skin (*sarnais*). Photo shows two workmen *mallahs* with their *sarnais* inflated, and carrying them on their backs.

Photo 7, shows *sarnais* in action. In front, is shown a *mallah* lying on top of inflated skin with his legs and parts of his body in water. He moves himself along, in water, by using his legs and a small wooden paddle. In the background is seen a twin *sarnai*, carrying a *charpoy* tied to them, and manœuvered by two *mallahs* on seperate *sarnais* on each side of *twin-sarnai*.

APPENDIX I

WOOD SUITABLE FOR MAKING DOWELS

Wood for making dowels should be fairly straight-grained and should be capable of being seasoned satisfactorily without degrade. It must also possess high strength in shear and compression parallel to grain.

Babul is the standard wood for disc dowel. When babul is not available the following species would also serve the purpose.

TABLE I

Safe Working Stresses of Species suitable for making disc dowels, in order of preference*

Sl. No.	Species	Shear lbs. per sq. in.	Compression parallel to grain lbs. per sq. in.	Localities where available (Only in small quantities)
1	Babul (*Acacia arabica*) ..	315	1600	Bombay, M.P., Madras. (U.P., Punjab, Bengal).
2	*Dhaman* (*Grewia tiliaefolia*)	265	1700	Bombay, Madras, M.P.
3	*Irul* (*Xylia xylocarpa*) ..	260	1550	Bombay, Madras. (M.P.).
4	*Sissoo* (*Dalbergia sissoo*) ..	240	1300	Nepal, U.P. (Punjab, Bihar, Bengal, Assam, M.P.).
5	Rose wood (*Dalbergia latifolia*)	240	1300	Bombay, Madras, Coorg. (M.P., U.P., Orissa).
6	*Sandan* (*Ougeinia dalbergiodes*)	250	1200	Bombay, M.P., Bihar, Orissa, U.P.
7	Axle-wood (*Anogeissus latifolia*)	235	1350	U.P., Bihar, Orissa, Bombay, Madras, M.P.
8	Andaman padauk (*Pterocarpus macrocarpus*)	275	2050	Andamans.

* Information obtained from *Indian Forest Leaflet* No. 31 (Utilization).

Separate copies of this article can be obtained from the P.L.O., F.R.I. and Colleges, Dehra Dun, on payment.

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A METHOD TO INDICATE THE PERCENTAGE OF LAND WHICH SHOULD BE UNDER FOREST

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Regarding the percentage of land which should be under forests in the hills and in the plains, widely divergent opinions have held the field. In the beginning of this century, the general opinion was that roughly a fifth of the land should be under forests and no difference was made between the hills and the plains. Later it was felt that the hills should be considered apart from the plains and that in the hills the percentage under tree growth should be 60, and in the plains 20. Recently a higher percentage of $66\frac{2}{3}$ has been suggested for the hills. No one has so far discussed the data on which these figures are based, nor is there any published literature on this subject.

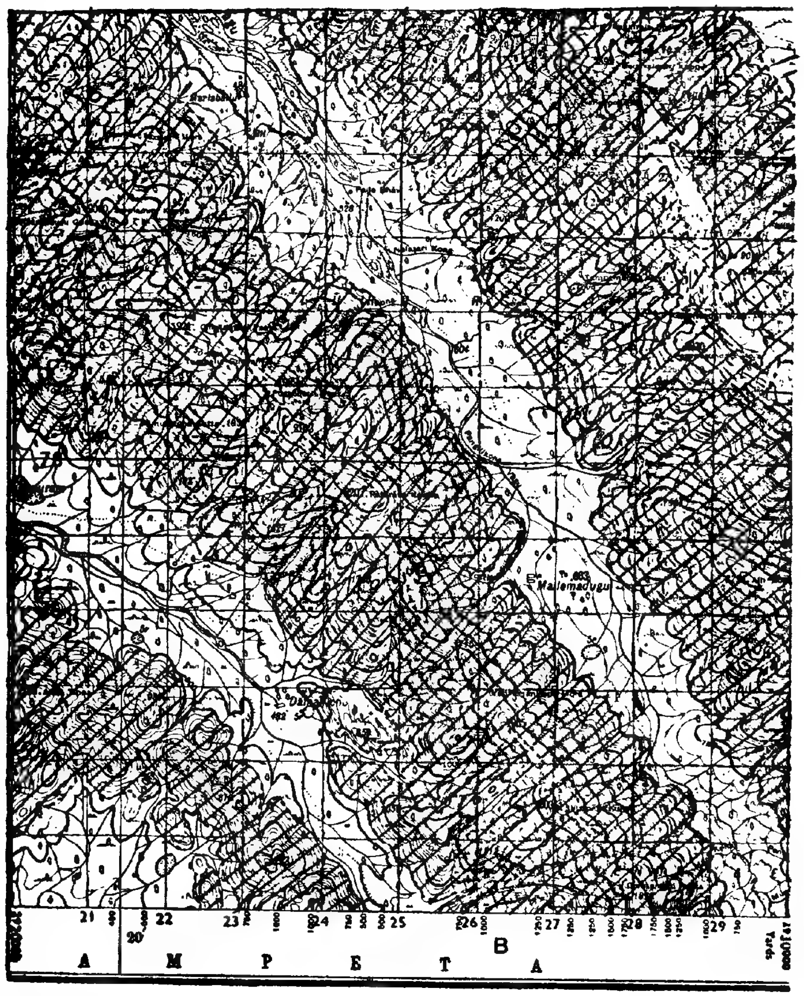
There is no special sanctity behind these figures, and the correct percentage for each locality can be determined only on the basis of a regular land use survey. But such a survey will mean much time and expense. It was in these circumstances a method, which will give for planning purposes a fairly accurate idea for each tract, was devised by the writer, and this is described below :—

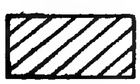
A general idea of the percentage of land which should be under forest can be obtained from any Survey of India topographical map, which shows contours. According to American literature*, lands having a slope between 12 to 20% should be under legumes or grasses for hay and pasture. Only moderate grazing should be allowed in such localities where erosion damage is moderate, i.e., 25 to 75% surface soil removed. Where the erosion is more severe, the land should be dedicated either to permanent legumes, or grasses for hay only, or forests. In steeper slopes, forests afford the best insurance against soil wash. In India, as forests have to provide pasture as well, it is generally considered desirable to have all lands above 12% slope under forests. Even this percentage depends on local factors which include a knowledge of the stratigraphy and the rocks of the tract. But whatever figure may be considered to be the critical slope, this method can be used. A 12% slope corresponds to a difference in elevation of about 635 feet in a mile.

In a 1 inch to 1 mile topographical map prepared by the Survey of India, the contour interval is 50 feet. Therefore, in the portion of the map showing a tract having a 12% slope, there will be 635/50 = 13 (nearly) contour lines to an inch. This means the distance between adjacent contour lines in such a map will come to a thirteenth of an inch. This gives an easy method of spotting on the map, areas steeper than the critical slope of 12 per cent . All portions of the map where the adjacent contour lines are nearer than a thirteenth of an inch will be steeper than the given critical slope of 12% and such lands should be under forests. Fig. I shows a Survey of India topo sheet, in which the areas which should be under forests have been marked, the critical slope assumed being 12 per cent. The interval between adjacent

* Soil Erosion and its Control—Ayres—McGraw Hill Publication, page 323.

contour lines will no doubt vary with the value of the critical slope and the scale of the map, but they can be easily calculated according to the method outlined above.





LAND STEEPER THAN 12% (TO BE DEDICATED TO FORESTS

CONTOUR LINES SHOWN IN BLACK CONTINUOUS LINES.

[Reproduced from Survey of India Map, Sheet No. 50 N/7 with the permission of the Surveyor General of India.]

In the original of this map which is on an inch to one mile scale, in the shaded portion the distance between the adjacent contour lines is less than a thirteenth of an inch.

In the plains, where such critical slopes do not occur the forests need not be more in extent than is necessary to meet the local demands for forest products and to afford protection against desiccation by wind and erosion caused by wind and water in the tract. Protective forests have to be dispersed according to a certain pattern to afford maximum protection and this can be combined with the primary object of meeting the local demand for

forest products. Taking protection alone into consideration, the forests need rarely be more than 10% of the land area, as shelter belts and wind breaks are supposed to give protection leeward from 10 to 15 times their heights. But for meeting the local demand, the extent under forests and tree growth will depend on the density of population.

For urban areas in Madras State, where internal sources of firewood do not exist and into which all firewood had to be imported, past and wartime rationing experience revealed that provision for fuel should be made on the scale 1/6 of a ton per capita per annum. For rural centres, where other sources of fuel, like dried leaves, twigs, and crop residues can be obtained, 1/8 of a ton per capita per annum was considered to be sufficient. On this basis, where the density of population is 500 per square mile, provision will have to be made for supplying in a sustained fashion 62·5 tons of fuel per annum per square mile of the tract. This quantity of firewood may be expected from 4 acres of forest in 25 years, in tracts having a rainfall of over 30 inches per annum. Therefore, the total forest area necessary to meet this demand in perpetuity will come to 4 acres $\times$ 25 = 100 acres. That is, for every square mile, with a population density of 500, one hundred acres will have to be under forest. For meeting the local demand for poles, agricultural implements and small timber, another twenty-five acres may be dedicated. On the whole, about 125 acres for every 640 acres (1 square mile) of land, should be under forest to meet the domestic demand for forest products of the 500 people residing in that square mile. This comes to 19·5% of the total land area. If the industrial and railway demand for timber has also to be met naturally more percentage of land should be under forest. Where the density of population is less, naturally the area under forest may be diminished. It is not necessary to have these forests in every square mile of land but then, protective forest belts may have to be raised wherever necessary. The forests can be raised in convenient groups in suitable localities, where the pressure on land is not much. Possibly, if within economic distance of the centres of demand, tracts enjoying higher rainfall and suitable for raising forests occur, they can be dedicated to forest. Then even smaller extents of forest will do. The idea is to confer the maximum benefit, both direct and indirect, on the people of the tract and a suitable pattern can no doubt be devised.

In tracts having a rainfall less than thirty inches per annum, as the rate of plant growth will be slow, more area may have to be under forest. The actual extent, however, may be easily calculated on the lines mentioned in the previous paragraph.

It is hoped that the methods outlined above will be found suitable for adoption in the different parts of the country.

A REVIEW OF WORK ON INDIAN TREE DISEASES AND DECAY OF TIMBER AND METHODS OF CONTROL

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SUMMARY

The paper deals with the various problems investigated during the past two decades, connected with diseases of Indian forest trees and decay of timber and discusses methods of control suitable to local conditions.

In its natural habitat sal (*Shorea robusta*) is susceptible to the attack of many parasitic fungi causing major or minor diseases. The predisposing factors have been analysed in detail and controls suggested from the mycological as well as the silvicultural points of view.

Shisham (*Dalbergia sissoo*), either grown as a pure crop or in admixture with *Acacia catechu* or *A. arabica* is susceptible to root-rot diseases due to *Ganoderma lucidum*, and vascular-wilt due to *Fusarium* sp. Controls have been worked out in the form of suitable admixture with resistant species, and protection against wound parasites.

Wide spread mortality of *Casuarina equisetifolia* due to *Trichosporium vesiculosum*, a wound parasite, has been reported in some of the most thriving plantations. Manuring and deep planting to overcome malnutrition and drought, and the discontinuation of pruning and lopping are suggested as control measures.

Teak (*Tectona grandis*) for *Olivia tectonæ*, *Uncinula tectonæ*, *Phyllactinea corylea* and *Nectaria hæmeatococcus ; Gmelina arborea* for *Gnomonia* sp. and *Evodia roxburghiana* for *Mycosphærella* sp., have been examined. Work on *Santalum album* attacked by spike-disease has been reviewed.

Investigations on coniferous rusts including *Cronartium ribicola* on *Pinus excelsa*, *C. himalayense* on *P. longifolia*, *C. quercuum* on *P. insularis* and *Peridermium cedri* on *Cedrus deodara* have been completed. The controls prescribed aim at the eradication of the weed host and raising an admixture of conifers and broad leaved species in new stands.

A preliminary study of the root and collar rot disease of *Cedrus deodara*, *Pinus excelsa* and *Picea morinda* due to *Fomes annosus*, *Polyporus circinatus* and *P. schweintizii*, which take a heavy toll of these conifers in the Himalayas has been made. A recent survey in the Himalayas reveals an increase in the incidence of diseases due to these fungi.

The work on the timber-decaying fungi includes the study of the biology and pathology of about 250 species, of Hymenomycetes attacking both hardwood and softwood timbers. The virulence of these fungi is determined by laboratory tests on wood blocks and toxicity tests are conducted by the same methods to work out the efficacy of the various wood preservatives.

The trees in India are mostly native species. In their natural habitat they have become adjusted to diseases caused by native fungi which ordinarily do not cause any serious epidemics. The diseases may assume a severe proportion due to change in the internal and especially external conditions, such as climatic, edaphic and biotic, under which the trees grow. The diseases should, therefore, be correlated with the predisposing factors and control measures against them can proceed based on sound silvicultural practices.

With respect to the diseases of the native trees, sal, *Shorea robusta*, a valuable hardwood species suffers from many diseases, the important ones being the 'unsoundness' (or hollow

heart) due to *Fomes caryophylli* (Rac.) Bres., *Fomes* sp. and *Trametes incerta* (Currey) Cke. ; root and collar rot due to *Polyporus shoreæ*, Wakf. and *Fomes lamaœnsis*, Mont. ; and canker on the stem due to *Hymenochæte rubiginosa* (Schrad.) Lev. Besides these, there are about 24 secondary parasites causing sap and heart rot and canker and some are important from the economics of sal. All these fungi are widely distributed in the sal-growing regions, some attack the tree where the species grows healthy and others where sal suffers from adverse circumstances like frost, drought, water-logging, fire, suppression, injury, bad management, etc. The fungi may attack the sapwood and in the pole stages kill the trees or they may be established in the heartwood causing cull in the merchantable timber. In some regions, sal has become so badly affected by the diseases that the forest is gradually depleted of this valuable species and also its associates like *Anogeissus latifolia*, *Lagerstrœmia lanceolata*, *Terminalia tomentosa*, *T. belerica*, etc., which are also susceptible to attack by these fungi. The result is that the forest is gradually reduced to a scrub forest – a stage in transition to a barren land. The forests on the Chota Nagpur hills and along the escarpments of Vindhya ranges which are the catchment area of monsoon rains form the principal watersheds feeding four great rivers of Peninsular India. The depletion of the forests in this region has produced serious repercussions like erosion and floods in the States.

Control to these diseases of sal requires immediate attention. To begin with, a pathological survey should be done in sal-growing areas and stock maps prepared to indicate the incidence of the diseases in different localities. One of the main causes of injury in tropical forests is fire. Protection of young regeneration from fire is essential as many heart-rotting fungi gain entry into the host through the resulting wounds. Frost and drought which also predispose sal to fungus infection can be controlled through sustained silvicultural operations. A sound hygiene should be practiced such as removal and destruction of diseased trees from forest, examination of stumps for rot during coppice felling and rejection of such standards if found rotted. These measures will reduce fungus inoculum from the forest. Frost-hardy species in the sal regeneration should be encouraged. It is advisable to encourage the volunteer species which colonize the land in a sal forest where sal is on the decline in the hope of re-establishing sal in near future. In view of the fact that sal is prone to attack by so many diseases, pathological marking rules should be strictly adhered to in working plans dealing with sal management.

Teak, *Tectona grandis*, which grows in the South India is raised both from seeds and stumps, both of which are free from fungus attack. The wood in a standing tree or when used in service is also free from attack by any wood destroying fungus. There are, however, some leaf diseases due to mildews like *Uncinula tectonæ* Sal, and *Phyllactinia corylea* (Pers.) Karst. and rusts like *Olivia tectonæ* (Rac.) Thirum. *U. tectonæ* is prevalent in coastal regions of Bombay, valleys of Madhya Pradesh and Coorg and in the foot hills of the Himalayas. The disease causes premature defoliation and may render the tree leafless. *P. corylea* attacks teak when grown in the neighbourhood of shisham which is the primary host of the fungus. Both the mildews rage into an epidemic form when humidity and temperature are high. The rust is prevalent in the dry regions and plateau of Mysore and Madhya Pradesh and causes defoliation. The extent of damage done to the tree by these fungi has not been ascertained but heavy defoliation certainly weakens the vigour of the tree. A leaf disease of such a virulence can be effectively controlled by spraying and dusting the aspects of work which still remain to be done on trees in India. Teak suffers from frost injury and in the Uttar Pradesh, such trees are later attacked by *Nectaria hœmatococcus* resulting in canker, while in Madhya Pradesh, the frost affected trees develop a hollow heart due to attack of indeterminable wood-rotting fungi.

Wilt and die-back of shisham (*Dalbergia sissoo*) are widespread in plantations in N. India. A species of *Fusarium* causes wilt of young trees up to 15 years of age. Mature trees suffer

from die-back due to attack by the root-rotting fungi like *Ganoderma lucidum* and *Polyporus gilvus*, the last two also enter the host through frost cankers. The widespread mortality of shisham in the taungyas (Agriculture-cum-forestry management) is due to root injury during frequent cultivation of the land which makes the plants susceptible to attack by *Fusarium*. The root-rot fungi attack them subsequently. Shisham planted along canal banks in the Punjab are attacked by *G. lucidum*. Erosion exposes the roots which get bruised by grazing cattle, etc., and through such injury the fungus enters the host. Shisham is found to grow healthy in admixture with other hardwood species like *semul*, *gambhar*, *jaman*, *Bauhinia*, etc., in the forests of North Uttar Pradesh. In the riverain tracts, shisham flourishes in admixture with babul and khair. In the taungyas, therefore, shisham should be grown in association with resistant hardwoods and not as a line of pure crops as is practised at present. A checker board method of plantation using the species in various admixtures should be worked out to find as to how best the system can be adopted. Similar system should be adopted in plantations along canal banks where care should be taken to protect the plantations from grazing cattle, etc. Period of cultivation should be minimized to lessen the chances of root damage. The rotation between two succeeding crops should be of such a period as to eliminate the fungal inculum in the soil.

Rosewood (*Dalbergia latifolia*), *Pterocarpus marsupium* are both subject to attack by heart-rotting fungi like *Polyporus gilvus* which enter the host through cankers caused by frost and fire to which the species are susceptible.

Casuarina equisetifolia, an introduced plant, has naturalized in coastal and inland areas of South India where the species is grown extensively for fuelwood. For sometime past, widespread casualties are reported from the plantations. In some areas, particularly those adjoining seacoast, where the soil is pure sand, there is a complete failure of the plantations. The plants become stunted and slender, and never grow tall and stout like those in healthy plantations. Poor soil which is deficient in nutrients and successive failure of monsoons resulting in drought appear to be the causes of such failures. Enough capillary action is not developed by the sand particles, which are coarse, to raise the water from water-table to the surface where most of the roots lie. The roots die due to lack of sufficient moisture and along with it the root nodules. Since the bacteria within the root nodules fix atmospheric nitrogen, the only source of replenishing an otherwise barren substratum is lost when the nodules die. Measures to raise healthy stand in these areas include manuring in pits prior to transplanting, deep planting and watering the seedlings for a longer period than 18 months as usually practised. These measures will help the growth of vigorous plants with long tap root system which will be able to draw water from the water-table. Leaf and litters should not be removed but allowed to remain on the floor of forest to the action of litter decaying fungi and microbes to replenish the soil.

In other areas, the trees grow tall and healthy attaining a height of 40–60 feet and g. b. h. 12–25 inches in 3–4 years but wilt subsequently due to attack by *Trichosporium vesiculosum*. The fungus is known to be a wound parasite. Pruning of branches which is practised when the plantations are 3–4 years old or illicit lopping cause injuries through which the wind borne spores of fungus gain entrance into trees and establish in a plantation. Secondary spread of the disease occurs through roots by root-contact and root grafting. A control of the disease is possible by preventing pruning or illicit lopping of branches which will prevent primary infection in plantations. Removal of diseased trees will reduce inoculum of the fungus and thus lessen the chances of infection. In cases where the disease is known to be spreading from definite centres it is worthwhile to trench out the diseased trees and remove them along with their infected roots. This will check the spread of the disease through soil. Hygienic methods like removal of diseased roots should be done before planting a stand.

A serious outbreak of a disease of gambhar (*Gmelina arborea*) was experienced in plantations of New Forest, Dehra Dun in 1930. The pathogen produced symptoms of leaf spots and affected leaves fell off. Young twigs, buds and later the stems were affected giving the symptom of die-back. The coppiced stools were also affected and killed. About 6 plantations within a radius of 2 miles were completely wiped out by the disease in course of 6 years. The fungus identified as *Gnomonia* sp., close to *G. veneta* had pleomorphic conidial stages which caused initial infection while the perfect stage developed on fallen twigs, etc. It is interesting to note that *Alcides gmelinæ* and a tingid bug were associated with the disease. A virulent disease like this could have been controlled by spraying which should have controlled the insects probably responsible for disseminating spores of the fungus.

Babul (*Acacia arabica*) and khair (*Acacia catechu*), both economic species and grown extensively in N. India especially in riverain tracts, are subject to attack by *Ganoderma lucidum* which attacks usually the roots and *Fomes badius* which enter both through roots and stem cankers. These fungi attacks the heartwood and in plants like khair, reduces considerably the yield of '*katha*'. Sound silviculture will reduce infection and maintain a healthy stand. It may be pointed out that fungi like *Fomes badius, F. senex, F. rimosus, F. durissimus, F. fastuosus, Hymenochæte rubiginosa* and others are wound parasites on various hardwood species and cause considerable cull in the merchantable timber. A method of preventing the spread of such heart-rotting fungi is to fell the affected trees and convert them. This will not only give the maximum yield of sound heartwood but at the same time remove sources of inoculum and consequent spread of the disease.

The spike disease of sandal (*Santalum album*) has spread to most of the sandal areas where it is found in an epidemic form. In the affected trees, the leaf is progressively reduced in size with the advance of the disease and become pale bluish-green which often changes reddish. The internodes are shortened. The spiked branches bear no flowers or fruits, except occasionally in early stages and exhibit the phenomenon of phyllody. The period of vegetative growth is prolonged and in advanced stages of the disease, the haustoria and fine root-endings of the tree are invariably killed. The disease has been successfully transmitted by budding, patch-grafting and leaf insertion, and is, therefore, believed to be of the nature of virus. In nature the insect vector, *Jassus indicus* is probably responsible for the transmission of the disease.

The spread of the disease may then be checked by controlling the insect vector. A belt varying from 100 feet to 2 furlongs, depending on the number of trees affected, should be demarcated and inside this belt all spiked trees should be uprooted or killed outright by application of arsenic. All sandal in the affected areas should be lopped off branches below 2 inches in girth, since lopping helps in the manifestation of the disease in the form of symptoms in a plant in which latent infection is present. The disease remains in a latent state in the tree for 4½ to 7 months after infection. This is the disease masking stage. After that period, the disease manifests in the form of external symptoms and it takes from 2–36 months for a spike tree to succumb. A sandal tree in both the disease masking stage and spiked stage is a potential infector and since affected trees in the disease masking stage cannot be detected, control measures appear difficult. Our knowledge on the spike disease of sandal is far from complete and we have not been able to control the disease. The insect vectors transmitting the virus should be discovered before control measures can be effective. Several instances are known where extensive sandal forests have remained free from spike disease. What factors confer immunity to these trees are not known. Breeding varieties resistant to diseases may prove successful in combating the disease.

Salai (*Boswellia serrata*) grows in the hot and dry parts of Central India. In order to open out the land as also to practice shifting cultivation of "Jhooming", the hill tribes

burn the forests which results in injury. Wood-rotting fungi like *Fomes rimosus*, *F. fastuosus*, *F. senex*, *Hexagonia sulcata*, *Trametes incerta* enter the trees through fire scars and cause heart rot, the indications of which are noticed in deformations such as bulbous and swollen bases, bottle-shaped stems in immature trees. The rot progresses as the tree matures rendering the trees useless.

Evodia roxburghiana, an indigenous species, grows healthy in a small percentage in admixture with other hardwood species in the evergreen forests of the Malabar coast in South India. There is, however, a large scale mortality when this species is grown extensively as a pure crop. The leaves of the diseased trees present a mottled appearance and is heavily infected by a nematode. A species of *Mycosphærella* has been isolated from diseased leaves.

Our coniferous species are found in the Himalayas and important diseases on them are caused by rusts and also due to fungi causing leafspots, needle casts, stem cankers, root and butt rot, and heart rot. The leaf spot and needle cast diseases have not yet been investigated. So far 17 species of leaf and stem rusts have been worked out, of which 4 are of economic importance. They are *Cronartium himalayense* on *Pinus longifolia*, *C. ribicola* on *Pinus excelsa*, *C. quercuum* on *P. insularis* and *Peridermium cedri* on *Cedrus deodara* of which the first three cause stem diseases producing canker and gall and the last leaf disease. The biology of 11 species have been worked out by cross inoculation experiments on both alternate hosts and with 3 others, they have been studied on one host. In the latter group, *P. cedri* which produces 'witches brooms' and finally die-back, has been found to be autoecious. The control of rusts which are heteroecious, having two hosts, can be done by eradicating the broad leaved alternate hosts which are either annuals and weeds or economically inferior species in the coniferous forests. The needle rust due to *P. cedri* can be controlled by admixture of conifers with broad leaved species. *P. cedri* on deodar can be controlled by removing diseased parts.

Fomes annosus and *Armillaria mellea* are the principal fungi causing root and collar rot. Deodar which is the most valuable among conifers is known to suffer adversely from attack by *F. annosus* in badly drained soils and in deep gullies where in winter the snow remains for a longer time and at altitudes above 8,000 ft., or so where deodar does not flourish. Fire which rages our forests annually causes scars, scorches the roots and stems and predisposes trees to attack by *F. annosus*. Thinning results in colonization of stump roots and felled logs by *F. annosus* which builds up to a great proportion in the forests. Selection of site, prevention of wounds due to fire and treatment of cut stumps with a preservative like creosote during thinning operations are some of the measures to be adopted to prevent *F. annosus* taking an epidemic proportion. *A. mellea* is ordinarily a parasite on the high-level oaks in the Himalayas. There is a tendency for the conversion of the mixed forests of oaks and conifers to pure stands of the latter consisting of deodar or spruce and fir since the conifers are economically important species. This policy is unsound from pathological view-point since the fungi like *A. mellea* and others begin to parasitize conifers in absence of the hardwood species. Our policy of management of forests in the hills should be changed and conifers should be grown in admixture with hardwood species and efforts made for a better utilization of the latter.

A major disease of blue pine (*Pinus excelsa*) is caused by *Fomes pini* in the Western Himalayas particularly in the Hazara division of the N.W.F.P., Kulu, Bashahr, Seraj and Simla divisions of the Punjab and in 4 out of 8 divisions in Kashmir. The fungus is also known to attack deodar, *chir* and fir but the attack on these hosts is not widespread. The high rate of infection in blue pine is probably due to heavy lopping to which the species is subjected. Blue pine is an important timber species and in its natural habitat, it regenerates easily and thrives well on a site where other softwoods are difficult to raise. Due to high

incidence of the disease, blue pine is getting ousted from this region opening up bare hill slopes.

Control of *F. pini* can be secured by preventing lopping of branches since it is through wounds and branch stubs that the fungus enters the host. Diseased trees should be marked out in the initial stages of attack and converted and the land may be restocked with sound trees. Such removal will prevent sporophores forming on infected trees and check the spread of the disease. Information at present available on the effect of *F. pini* on wood shows that there is little weakening of the timber showing incipient decay by the fungus. Removal of affected trees and their conversion may be used for purposes where sound wood is prescribed. The progress of rot ceases immediately after conversion. Hence the wood in initial stages of attack can be used with safety.

Among the phanerogamic parasites, the important ones are *Arceuthobium minutissimum* which attacks young regeneration of *Pinus excelsa* in the dry zone of the inner Himalayas at high elevations as for example in the Upper and Lower Bashahr in the Himachal Pradesh, Kulu in the East Punjab and in 4 divisions of the Kashmir State. Species of *Loranthus* are parasitic on sal, shisham and other hardwood species. Doddar, *Cascuta reflexa*, attacks herbaceous plants and small trees in the plains while in the hills, *Viscum album* parasitises oaks and other hardwood species. Eradication of the parasite during thinning, pruning and other silvicultural operations is the effective method of controlling the disease.

It is estimated that approximately 350 species of wood-destroying fungi cause active decay of which the biology and pathology of about 250 species have been worked out. Proper utilization should aim at protecting the timber from attack by these fungi. Healthy timber after it has been seasoned should be used. In instances where the wood is found decayed, the organism causing the rot should be identified, the progress of rot in the wood should be determined and the wood graded according to severity of infection. If the wood is in an incipient stage of decay, it may be used after adopting prophylactic measures like treatment at a temperature sufficient to kill the fungus or by application of wood preservatives. Even the sound wood should be treated with wood preservatives particularly when the wood is used for outdoor service because high humidity and high temperature in our country are favourable to the activity of decay fungi which cause a rapid rot in the timber. In this connection, tests have been carried out in the laboratory to know the suitability of various chemicals as wood preservatives. Experiments to determine the natural durability of timber when the latter is put in service are also under contemplation.

Reports of failure with exotic species of recent introduction have been many and these are due to unsuitable environment or due to introduced disease. Chestnut blight, *Endothia parasitica*, has recently been reported from Ranikhet in the Uttar Pradesh on chestnut, *Castanea sativa*, an exotic tree grown in the Himalayas. Though the chestnut has no timber value with us, it is grown as a horticultural species. The disease has caused considerable damage to chestnut in America and Europe where the fungus also attacks other hardwood species like oaks, maple, etc. The reported occurrence of the disease in India is, therefore, of serious concern. The disease should be identified as soon as it breaks out and the chestnuts eradicated. The disease has presumably been introduced in India through diseased plant materials. Quarantine measures should be enforced to prevent entry of any diseased chestnuts and in fact, any diseased materials when such plant specimens are meant for introduction in India. Mortality of *Khaya senegalensis*, *Acacia mollissima* are some of the instances to this. The wattle (*A. mollissima*) suffers from a gummosis disease and isolations from diseased trees have failed, so far, to yield any fungus. A word of caution in growing exotic species in so far fungus diseases are concerned is that such trees in unsuitable environment are liable

to attack by fungi which may take up an epidemic proportion since the introduced species has not developed a natural resistance against the fungus pathogens of that area.

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GREGARIOUS FLOWERING OF *DENDROCALAMUS STRICTUS*

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SUMMARY

The flowering of *Dendrocalamus strictus* is defined and the life-cycle with particular reference to U.P. where it is deduced to 40 years, is discussed along with the recent flowering in Lansdowne Division. Causes of flowering and the various factors affecting flowering are also described and discussed.

Introduction—*Dendrocalamus strictus*, the commonest bamboo of India, belongs to the tribe *Bambuseæ* of the primitive family *Gramineae*, most of the species of which are the grasses - annuals, flowering and dying every year. Indian bamboos are slightly modified and specialized forms which unlike trees and shrubs of other natural orders, flower only once during their life-time* and soon die. It would appear that they attempt to perpetuate their species by flowering and seeding before death. This unique phenomenon is also commonly found in a large number of species of insects where the males die soon after copulation, as if the purpose of their existence was nothing more than reproduction.

Definition and Types—Two types of flowering in Bamboos have been recognized ; gregarious and sporadic, the former is commonly attributed to flowering of all culms of all clumps in a certain area as against the latter, to flowering of one or a few culms in one clump or a few clumps in one locality. It would be seen from the above that these definitions are not very definite as the extent of area is not defined. A large scale sporadic flowering of all culms in a few clumps may easily be confused with a small scale gregarious flowering and vice versa. Terms such as non-gregarious but heavily sporadic, sporadic on a big scale and general flowering have been used by Deogan[1] in his excellent monograph on *Dendrocalamus strictus*. Troup[2] also admits that it is impossible always to draw a sharp line of distinction between gregarious flowering on a small scale and sporadic flowering on a large scale since the two merge into each other. In general, however, the term gregarious flowering is used only for areas over 5 acres and for all culms in all clumps but standardization would avoid confusion in the minds of many and lead to more accurate data becoming available.

Life-cycle—As the bamboo dies soon after flowering, the phenomenon is employed to determine the life-cycle, the period which elapses between two consecutive flowerings. This can only be done from observations and records of gregarious flowering as the sporadic flowering takes place almost every year in the same locality and probably many a time for several years in the same clump on different culms.

Troup[2] (page 981) wrote in 1920 "Some interesting facts have been recorded from time to time in connection with the flowering of bamboos but our knowledge of the subject is as yet very incomplete". Deogan[1] (pages 107–109) in 1936 has given quite a lot of information and data about the localities and the year of gregarious flowering, but this lacks definiteness regarding limits of locality as admitted by him. In some cases it is also doubtful whether the flowering was really gregarious or heavily sporadic. Since then, during the last 15–16 years, quite a lot of data has been collected and it would be desirable to revise this Indian Forest Record now. However, all this knowledge and data are still so inadequate that one

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* Only one exception is recorded for *Oxytenanthera monostigma* in Kanara Bombay by R. Morgan[3] who noticed two crops of flowers and seeds on the same culms.

can't be very precise about the life-cycle of *Dendrocalamus strictus* and speculation has to be resorted to.

Although *Dendrocalamus strictus* has been described as an irregularly flowering bamboo yet there is considerable regularity in this irregularity as the incomplete and inadequate data proves. Kurz[3], as early as 1875, noted the period to vary between 25 and 35 years. Troup[2] wrote "It may be assumed that the period between the two successive flowerings of bamboo represents its physiological life-cycle ; it is possible, more over, that this cycle may be influenced to a slight extent by climatic or other causes, but primarily it is determined by physiological causes inherent in the plant. That this period varies with different species is certain, whether or not it varies for the same species in different localities, is not known" ; and Deogan[1] (page 111) admitted in 1936 that "after the lapse of so many years with a number of flowerings we are still unable to be more precise than Kurz in 1875. We can only say that there may be a bigger variation, viz., 20–40 years or so".

So far as the Uttar Pradesh is concerned, I think we have passed the stage of speculation and can be fairly precise for the Siwaliks and outer Himalayan bamboo forests of the Western Circle. The recent Working Plan of Lansdowne Forest Division[4] predicted the flowering in localities near about Kotdwara and did not accordingly prescribe departmental working. This prophesy came quite true when gregarious flowering commenced in the year 1949 in Paniali block ct. 3 and 4 over an area of 315 acres[5] the flowering soon extended to ct. 1 and 2 of the block, as was expected and has since embraced the adjoining Sukhrao and Lalpani blocks over their entire areas. Gregarious flowering is also taking place in Khairgaddi block in ct. 1 and 2 over an area of 987 acres, and it is presumed that before long, this may extend to the whole of the division (except Chandi range). The various records of flowering for this tract are as under :—

	Year	Locality	Source of information
(A)	1870	Garhwal (outer Himalayan tract).	Brandis.
	1909–10	Paniali block of Lansdowne Division Garhwal.	Annual Report.
	1949–53	Paniali, Sukhrao, Lalpani and Khairgaddi blocks of Lansdowne Forest Division, Western Circle in District Garhwal.	Personal Inspection and D.F.O., Lansdowne.
(B)	1883–86	Saharanpur Siwaliks in general ; Ranipur block in particular (1885).	A. F. Brown.
	1925	Saharanpur (Ranipur plots).	Annual report.
	1926–27	Lansdowne Division Chandi range, Kalagarh Division.	E. Benskin.
(C)	1911	Jhirna block Bundelkhand Division.	Troup.

The flowering of the Paniali and Ranipur blocks prove beyond any doubt that the life-cycle is roughly 40 years. The prediction based on the past data turned out to be quite accurate and on the same analogy it could be predicted with a fair degree of accuracy that the Ranipur block would flower again gregariously in 1965 and Chandi range forests in 1966–67 in the Lansdowne Division. The present flowering in localities mentioned near Kotdwara is likely to extend further into adjoining areas next year.

The figure of 1919 for Kotdwara, Lansdowne Division quoted by Deogan in his monograph on Bamboos, and later on mentioned by Mathauda[6] in his note on flowering habits of Bamboos, appears to be a misprint for 1909. The source of information is not indicated in either case, and a further verification from the records of the Lansdowne Forest Division (Annual Reports and Compartment Histories) has further confirmed that the gregarious flowering took place in 1909-10 and not in 1919 as pointed out in the *Indian Forester*, Vol. 78, 1952 (page 86). The deduction of a 30 years cycle assumed by Mathauda[6] ignoring other previous data, therefore, in his above note is obviously incorrect.

Dendrocalamus strictus has also flowered in North Kanara in the Bombay province in 1947–52 according to Neginhal[7]. It had flowered in 1907–12 before and also gives a life-cycle of roughly 40 years.

The observations in the C.P., Mysore, Madras and Burma lead to a life-cycle, very considerably varying from 8 to 28 years. Rejecting the smaller figures, which are only few, it may be assumed that the average life-cycle in Burma and C.P. is 20 years. Kadambi[8] recorded wholesale flowering in Aldhara, Lakkawali, etc., in 1917–18 and again in 1932–33 adding that the previous flowering is said to have taken place in 1905–08. This gives a cycle of 12–15 years although he puts it down between 25 and 30 omitting the 1917–18 flowering. Only further data will bring out the exact cycle in these States, but the suggestion that in the U.P., the cycle is 20 years in place of 40, one record of intermediate flowering having been missed, is extremely unlikely in these too well known and highly intensively worked bamboo areas. The gregarious flowering in bamboo is a very conspicuous phenomenon and as already mentioned, all the clumps die after flowering and naturally the yield and the revenue for the next six to eight years drops down to zero – which facts can't escape unrecorded. On the other hand, it would not be too much to speculate whether the localities where a life-cycle of 18–22 years has been indicated have really not recorded a heavy sporadic or sporadic on a big scale flowering as gregarious. Only more accurate and detailed observations will bring out Nature's secret.

Sporadic flowering is commonly found in all bamboo areas almost every year and only the particular culms or clumps flowering, die. The exception in Nausi as noticed by Mathauda[6] seems to be rather strange as my frequent visits to the place in 1946, 1947, 1948, 1949 and 1951 always showed the usual sporadic flowering (I am not sure of the small experimental plots) in the forests. Being a cool place, as should be expected, the flowering is probably somewhat less than found in warm localities.

The cause of this sporadic flowering probably lies in the origin of the clumps from more than one seedling and the culms produced by the same seedling flower simultaneously.

Causes of flowering—Troup[2] has enumerated a large number of causes stimulating flowering, e.g., climate, old age, and has also added that the factors which determine the life-cycles of bamboos and the occurrence of general flowering are not yet clearly understood. Various instances disproving the climatic theory have also been given by him (page 983) by quoting the flowering of the seedling from the same parent stock. Deogan[2] (pages 112–113) in addition has mentioned physiological influences like accumulation of starch in the rhizome or a large reserve of sugar in the plant tissues, and system of working and has quoted examples in support of the theory.

There is thus quite a lot of dispute as to the actual causes which induce flowering, but the old age appears to be chief important factor in the flowering of the bamboos. The only instances of seedling flowering against this theory, are explained by the fact that the shoots seemingly of seedling origin, are really from some old mature rhizomes, as has been proved

by various experiments (Deogan page 111) conducted by various authors. Blatter's contention that all the clumps of a species don't flower after the same number of years may be due to existences of vareious varieties of *Dendrocalamus strictus*, hitherto undiscovered, due to widely varying climatic, biotic and locality factors all over India and Burma. However, further research is indicated for the problem.

Whatever be the cause of flowering, there is not the least doubt, that flowering is definitely affected by the above factors of climate, grazing, system of working and the like. It is a common every day observation in a bamboo forest that flowering seems to be more predominant and widespread in localities exposed to sun with dried stony soil on southern slopes as against the damp, cool and deep sandy loam on southern and easterly aspects. Similarly heavily grazed areas and those subject to maltreatment seem to be more easily susceptible to flowering. The heavy and over-worked clumps in easily accessible localities flower earlier than remote areas in the interior and obviously conservatively worked. The departmentally worked bamboo forests of the Punjab are said not to have flowered for the last 80 years while in the same locality, the private forests have flowered twice in 30 years although this needs further confirmation.

It, therefore, follows as a natural corollary that the reproductive age of *Dendrocalamus strictus* will be varying from locality to locality depending on the above factors. The variation in case of a particular tract, e.g., the Siwaliks and outer Himalayan tracts in Garhwal, may be so small that it may almost be taken constant and this period is most likely 40 years.

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GUM RESIN AND FOREST RESEARCH

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SUMMARY

To-day the pioneer in the field of Gum Naval Stores Industry is the United States of America. Through decades of patient and plodding research work in this field they have made the most far reaching improvements in their working technique in the forests as well as in the processing plants. A great deal of work shall have to be done in India if we want our resin industry to prosper and our forest wealth to be conserved in the best possible way.

The collection of exudate in peculiar V-shaped receptacles called "boxes" cut out of the trunk of the trees belonging to the genus *Pinus* of the Coniferae order is perhaps as old as history, but the basis of modern tapping practice, which consists essentially in the collection of the oleoresin in cups fixed below a more or less lightly chipped face is due to Hughes who gave it in 1844. With the box itself cut into the stump of the tree at its most vital point the trees were overworked and sometimes died. The danger of being uprooted and destroyed by wood fires was alarmingly great and the trees had little value as lumber. No timber could be worked for more than two or at most three years.

Hughes system of preventing premature decay of trees and depreciation of their value as lumber through complete elimination of deep cuts was adapted in France about twenty years later. Its remarkable success in conservation of the French forest wealth demonstrated during the next few decades prompted Dr. Herty[8] to undertake his well known series of investigations which have later proved to be, in no small measure, responsible for the emergence of the United States as the foremost producer of Naval Stores. In India the development of resin industry has been entirely the work of the officials of the Forest Department. After the successful conclusion of the preliminary experiments carried out under the Officer-in-Charge of the Forest College (then School) at Dehra Dun during 1890–95 tapping operations were started at Jaunsar in 1896[18] and in the selected areas of Kangra in 1897–98[9]. Indian Forest Officers trained in the French School of Forestry naturally at once adapted Hughes "cup and lip" method of resin collection as modified by Smythies[18,19] to suit working conditions in India.

Ever since the "cups and lips" have been the fringe of Kumaon and Siwalik forests the stress has been naturally on starting organized tapping in new regions hitherto considered inaccessible. In fact the times during which gum Naval Stores industry has enjoyed prosperity in India, as every where else, have been during and preceding a war. No one can say that the business is healthy when it depends for its continued profit on wars and rumours of war. We have, however, now arrived at a stage when for the youthful resin industry in India not to remain dependent for its very survival on the occasional periods of "high prices", we must pause and ensure that while increasing the area of operations we continue to maintain the maximum efficiency and utmost economy in the working of this industry. Our major costs are incurred in the forests and, therefore, the adoption of more efficient and less costly methods of gum collection in the woods becomes of crucial importance and must now engage our attention. Every tree must be made to yield more gum at less cost.

The application of chemical research to industry over the last four decades since Smythies standardized the current Indian tapping practice, has brought the most far-reaching changes in industrial efficiency and the U.S. Department of Agriculture through work at its

various research stations situated all over the Naval Stores belt has accomplished a great deal in rationalizing technique of pine gum production, thus lowering the costs and stabilizing the production at the same time. The object of this study is to give a brief synopsis of the developments which they have effected recently in this field.

Muttoon[14] studied the relationship between the diameter of the tree and gum yield and found that the yield from a tree 12 inches in diameter is nearly five times that from a 7 inch one. Croker[2] in his studies made in 1948 and 1949 on Escambia Experimental Forests in South Alabama found that widening the face width to tree diameter the overall gum yield per crop per season was increased by 58% which more than compensated the extra cost involved in chipping wider faces, the face width of 9 inches on an average tree diameter of 16 inches being increased to 14 inches. This conclusively brings out the importance of mature trees and the adjustment of face according to the diameter.

In a small test at Olustee[15] repeated heavy applications of a complete fertilizer to the soil increased gum yields from acid treated slash pine trees by 23% over a four-year period. Selection of the proper type of fertilizer and of the most economic quantity in relation to the gum yield will require much further study.

The development of bark chipping and acid treatment is decidedly a long step forward in reducing gum production costs as well as in keeping up the value of turpentined pine as lumber. While thin chipping was first recommended by De Bois[4] in 1851 German scientists had discovered during the first world war that the German *Pinus sylvestris*, otherwise a low gum yielding tree, could be induced to increase its yield through the application of Hydrochloric acid.

In U.S.A., however, Liefeld[12] was the first to carry out organized studies in chemical stimulation. Different concentrations of Sulphuric acid, Acetic acid and washing soda were tried and after two years of patient working he recommended weekly chipping and application of 40% Sulphuric acid[11] solution on slash pines for a 50% increased yield. Recommendations of U.S. Forest Service for chemical treatment for 1943 laid down for the first time the principle of bi-weekly chipping and acid application as it had been established that Sulphuric acid not only increases the rate but also greatly extends the period of gum flow from treated streaks permitting less frequent chipping without sacrificing the yield. Bi-weekly chipping besides lessening labour charges doubles the number of seasons a face can be worked since the face height increases only half as rapidly as in normal practice. This greatly increases the total amount of gum from a face and in all probability from a tree during its working life.

One theory, reported by Pomeroy[16], is that gum is hardened or crystallized at the ends of the resin ducts where they are exposed by chipping and this hardened gum plugs the tubes in the tree so that gum can no longer flow. Presence of about 0·33% of water in the gum causes it to crystallize and harden. Addition of water to a dehydrated gum sample which had remained clear and fluid for three years resulted in crystallization of the gum within a few days. This suggests that any treatment which dehydrates or prevents hydration of gum as it comes out of the resin ducts will prevent crystallization and thus prolong flow. A 50% solution of sulphuric acid apparently has this effect to a greater extent.

Later researchers, particularly Snow[20], established that acid application does not cause any injury or lead to a less helthy growth of the tree as compared to lumber turpentined according to the ususl practice and recommended 40% sulphuric acid as best for slash pine and 60% for long leaf. In fact Snow's researches paved the way to commercial exploitation of the principle of chemical stimulation and the number of acid-treated trees in commercial naval stores operations shot up from 3 lakhs in 1946 to 30 lakhs in 1948. This technique less than five years in commercial use, is gaining favour rapidly. In 1950[16] more than 11·7 million faces were treated with acid, and a recent survey indicates that 17·5 million faces, or about

25% of all these being turpentined, may have received acid by the end of the 1951 season in the United States. Pilot plant experiments made in 1948 with 50% solution of sulphuric acid, later found to be the most suitable both for slash and long leaf pines, revealed an average increase of 20% in gum yield. The grades of rosin obtained during a series of years showed that the average grade is slightly higher from the acid treated than from the adjacent untreated timber.

The latest results obtanied on the performance of the new method of bi-weekly bark chipping with acid treatment (50% sulphuric acid) both on slash and long leaf pines as compared with regular weekly wood chipping without acid have been reported by Clements[1] and McArthur[13]. The trials were carried out under actual operating conditions at Hoboken, Georgia and in Escambia County Florida. Trials carried out in 1948–49 on long leaf pines showed that 25% less gum was produced with the regular hack while the cost of production by using the bark hack and acid method was 22% below the regular wood hack method. Clement's[1] report about the test carried out in 1950 says that by bark chipping and acid stimulation on a two week schedule slash pine yielded one-third more gum than that obtained by wood chipping. To obtain the best results a consistent 14-day schedule should be maintained besides a thorough field supervision of the labour. In these tests one quart of 50% acid solution was found sufficient for application on about 1,000 faces.

"Split face[16]" system of bark chipping seems to be still more promising. This consists in two faces each one-sixth of the circumference of the tree separated by a 2-inch bark bar but both faces are served by the same cup and gutter system. Yields during a one year trial were 40% greater than a single one-third circumference face in slash pine and 7% greater in long leaf. Acid treated pines are valuable as lumber. Gruschow[7] reports about the trials carried out by the Granger saw-mill on 2,50,000 board feet of long leaf and slash pines ranging from 11 inches to 20 inches d.b.h., chipped and acid treated biweekly in actual commercial operations for five years before timber harvesting in 1949, with two faces placed on trees larger than 11 inches diameter. Felling cut was made below the face keeping it on the log, the presence of the face having no effect on the lumber behind it. The bark chipped face was completely removed in the normal slab cut in squaring the logs. The pitch soaking beneath the face extending from ½ inch to 1 inch was there but this was removed in slab and board edgings. The trees were treated as if they had no face and the loss in grade and yield was less than 1%.

Ostrom[15] in 1949 wrote that Langdale Company of Voldasta while determining the value of bark chipped trees for poles found that slash pine poles produced from trees by bark chipping on a two-week schedule for three years took preservative treatment satisfactorily through the face. The preservative penetration was poorer on similar untreated trees.

U.S. Forest Service has been attempting since 1947 to find a flow stimulant easier to handle than sulphuric acid. Preliminary studies carried out in 1949 showed that the wood killer 2, 4-D provided a considerable increase in gum flow though it caused some injury to the tree and the flow decreased towards the end of the season. Experiments in the use of 2,4-D to prolong gum flow have progressed to the pilot plant stage for slash pine but are unsatisfactory at all test stages on long leaf pine. In the trials made in the early part of 1949 with pitch canker fungus (*Fusarium Lateritium pini*) it was found that it equalled the performance of sulphuric acid as a gum flow stimulator. Later it has been discovered that infrequent chipping and inoculation of the fresh streak with the fungus have not given gum yields equal to those obtained with sulphuric acid, except in some special cases which are being further investigated by the Division of Forest Pathology of the U.S. Forest Service.

Though cross breeding of rubber, nuts and various fruit trees in order to accentuate their sap yielding or fruiting capacity has been a recognized commercial practice for a number

of years now, the application of this technique in developing high gum yielding strains of pines has, however, been a subject of organized study in the U.S.A. only since the early forties. Downs[6] has reported that the branch experiment station of Lake City made a start in this direction in 1942 by selecting after trials made in co-operation with the field staff and gum producers and extending over a season a dozen of high yielding trees which gave two or two and a half times as much gum as their adjacent trees under similar working conditions as breeding stock. Breeding of the selected stock was carried out as follows.

In January the purple male catkins or flowers forming on the major branches of the high yielders are collected, dried and yellow pollen shaken out of them to be stored for use. Sometime later when tiny conical female flowers grow on the tips of the uppermost branches of the other trees they are covered with "windowed" canvas bags to prevent them coming into contact with the unwanted stray pollen. When the female cones reach the right stage they are sprayed over by a large quantity of the stored selected pollen by means of a hypodermic needle inserted through the windowed bag which are removed after sometime and the cones allowed to grow. The actual fertilization takes place in spring. The fertile seed is fully matured in the following autumn. The cones are picked, seed extracted, de-winged and stored for planting.

This system of cross breeding has been followed in crossing high yielding slash pines with other high yielding as well as with medium and low yielding slash as also with fast growing slash, with high yielding long leaf and even with non-turpentine loblolly pine. It is expected that research in continued cross breeding and hybridization should go a long way in developing hybrids with many desirable characteristics, viz., high gum yield, rapid growth, better gum, greater vigour and disease resistance.

To activate germination of seeds various vitamin solutions and chemicals have been tried. The influence of physical factors has also been tested – artificial light, ultraviolet radiation, heat and coldness. Only coldness proved to be particularly interesting. In fact after treatment at low temperatures most of the living seeds were capable of germinating within several days. The technique[3] used in the treatment is as follows : The seeds after having swollen for 5 to 10 days at room temperature were put in a cold room at 20°C. for periods varying from 13 days to 10 months. The amount of water absorbed by the seeds equalled about 25% of their fresh weight.

The germinative energy was much higher for the treated seeds. At the end of seven days untreated seeds in the germinating house showed germination between 1 and 4% whereas percentage germination was 75% for seeds with 138 days treatment in the cold room and 94% for 192 days. The time of 192 days[3] gives best results since by increasing it further to 230 days the percentage went down to 82% only. Exposure to coldness is the best treatment for stimulating germination of maritime pine seeds.

Vegetative propagation[17] at least as far as turpentine yielding pines are concerned is admittedly in infancy still. Lake City Experiment Station of the U.S. Forest Service has been able for the first time in Naval Stores history to make successful attempts after repeated failures at vegetative propagation of pines.

Twigs from major branches from "high yielders" were cut soaked for 24 hours in rooting solution containing variable quantities of a harmone (indole butyric, indole acetic or traumatic acid), sugar, Vitamin B (thiamine chloride) which is a complete plant-food as well as fungicide. The soaked twigs were then planted in sterile sand flats in a green house where rate of mist spray and temperature were controlled during the day. Downs has reported that by this procedure 5 to 20% of the cuttings obtained from 15 to 30 years old trees have been successfully rooted. Cuttings from old trees generally and long leaf particularly proved extremely difficult

to root. Young slash pine cuttings were a considerable success. These twigs out planted reach a height of 15 feet after a lapse of only 6 years and have the characteristics of the parent tree. As research succeeds in overcoming various difficulties connected with this problem, e.g., finding the best rooting medium, etc., it will doubtlessly open to us a new vista in greatly shortening the time required in rearing high yielding stock.

Ever since Dr. Herty grafted the "cup and gutter" system from France there has been an evidence in the United States of a steady progress being maintained in improving the various items of equipment needed for turpentining trees and American gum farmers of the present day have travelled far from the days of medieval type axes, hacks, pullers and long handled dippers.

A major contribution of the U.S. Naval Stores research has been the stimulation of gum flow by the application of sulphuric acid. The steady progress in evolving standardized equipment required for its application has been responsible for its popularization and the consequent enormous multiplication of acid treated trees. The cheap paint brush in 1942 developed into a spray gum and later into an atomization type sprayer evolved by the University of Florida for the application of the acid. It was, however, in 1947 that the first squeeze type spray gum was introduced by Schopmeyer. Improvements in the original design have been made by M. E. Ryberg and H. W. Burney, technicians in the South Eastern Forest Experiment Station. The latest type acid applier is made of plastic polyethylene and its cone shaped nozzle also made of plastic is provided with an antidrip rim, anti-splash shield as well as a drop swallowing cup to avoid any wastage of the acid.

The chipper has to do the acid application besides bark chipping which entails upon him the task of carrying a separate piece of equipment in addition to his hack. On long journeys this is inconvenient. Attempts to combine both the hack and the sprayer into one tool showed that this had a tendency to drip during chipping and could not be squeezed at great heights. The Naval Stores Equipment and Mechanization project have now brought out a field model of a comparatively durable and low priced spray hack. In this less pressure is required for squeezing and a small trap has been incorporated to avoid dripping. A combined spray puller is being made for these gum farmers who reach pulling heights in due course.

Bark chipping results in a round face and, therefore, if the usual type straight gutters are to be fixed a preliminary incision into the tree has to be made. To avoid this and consequent loss of timber a new type of spiral formed gutter has been devised. The gutter designed by Ryberg, Burney and Clements is fastened with removable bill-poster or hide tacks using a clip or magnate type hammer. This is easily removable and reusable. The tapered hide tack is also simultaneously removed leaving the tree free of any metal and usable for making poles.

By early forties Hughes cup had completely been replaced at least in the United States by galvanized iron cup with a standard capacity of 1·37 quarts. Tests in 1948 had shown that 40% of the trips for the collection of gum could be saved by the use of a cup of 1·9 quarts capacity in place of the standard cup. A follow up study in 1949 revealed that the longer dipping interval permitted by the use of the larger cup had no effect on the turpentine content of the gum or the grade of the resin. The analyses were performed by Bureau of Agricultural and Industrial Chemistry at Olustee.

Glimer in 1911 had suggested to the French Naval Stores circles a new tapping system to obtain very clear gum with 30–32% essential oil content. Glimer's system recommends two tunnels bored under the foot of the tree and meeting at a common opening leading to a covered glass receptacle. Though of considerable interest, his suggestions remained only of academic value as it was not advisable to introduce huge numbers of easily breakable glass receptacles into the forests.

Recently, however, in U.S.A. attention has increasingly been rivetted upon exploring the possibility of employing disposable paper bags for collecting resin. To-day the paper technologist is in a position to produce a cheap, wet strength, plastic coated, weather resistant paper and bags from it could be attached to the tree by a hand stapling machine without using any nails, etc. As paper can be made to conform to the shape of the chipped face it will eliminate the use of gutters. A detailed study into this problem is being made by the Naval Stores Equipment and machanization project and is expected to give interesting results of far reaching economic importance.

Gum collection operations so far defied mechanization but when planned orchards now being widely planted in the U.S. Naval Stores belt grow to working heights in a few decades it will be an accomplished fact. The haphazard growth of pine trees in nature necessitates the coverage of an enormous forest area to reach a sizeable number of working trees through a very large unproductive walking, often over dense growth and troublesome wet ponds. The natural Georgian stands at present being tapped have been estimated to contain about 25 working trees per acre giving a total annual gum yield of about 200 lbs. Smythies report about Kumaon forests says that the number of working trees per acre in these forests is only 20 with an annual yield of 123 lbs.

Dorman[5] considers that a planted turpentine orchard should have at least 242 trees per acre or nearly 10 times the average in natural stands. This will eliminate unproductive walking altogether and would enable the chipper to increase his weekly chipping average from 5,000 to 20,000 or 30,000 trees. With selected high yielding stock worked by the latest methods the annual acre gum yield would be expected to be of the order of 3,500 lbs. or over 22 times the average of to-day. Mechanization will be a possibility, nay, even a necessity as such high yield would invariably require much more frequent dippings even after using large cups. Recently a typical planned orchard has been planted in Stone Country, Mississipi where in a 700 acre area, over 156,000 trees have been planted within four years by a central tree-planter.

In Escambia Country of Florida they have passed a special set of legislature[10] in 1947 and brought into being a fully representative agricultural extension council, composed of eleven members, for the purpose of furthering agricultural and forestry development. The Board of Country Commissioners acting on the advice of this council have entered into an agreement with Florida Forest Service to establish the Country Forest project to provide the services of a professional forester to landowners in helping them solve their forestry problems, setting up private nurseries and to encourage better turpentine practices. In this way a huge area cut up into small tracts has been brought under improved management and made to yield an over increasing revenue.

Improved turpentining practices, pioneered through decades of research at various research stations situated throughout the Naval Stores belt, have accomplished a great deal for the United States. Bark chipping and acid stimulation, development of new tools and equipment, studies in selective cupping and various other findings have gone a long way in reducing the cost of gum production. They have even gone to the extent of passing legislations as an experiment for furthering developments. It will, however, not be out of place to mention here that while studies in all these cases were initiated by the Forest Service, the results achieved through them can only be ascribed to the co-operative effort of forest labour, gum farmers, landowners, and Federal and State Governments.

India as regards forest research to improve the turpentining methods is far behind. We are still continuing the old method of gum extraction and its collection. Practically nothing has been done to improve our gum yields from *Pinus longifolia*, Roxb. which is most abundant in our country. We must see that our national forest resources are used carefully

and conserved intelligently. Studies will have to be taken up in bark chipping and acid stimulation, selective cupping, selective breeding, better equipment, vegetative propagation and a host of other problems to see what can be done to improve our forest wealth. This will require action on the part of foresters, industrialists, Government and researchers but the action must be based on sound scientific knowledge of forestry and its problems.

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STRENGTH OF BAMBOO (*DENDROCALAMUS STRICTUS*)

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SUMMARY

Bamboo has recently attracted considerable attention for use as a constructional material. It grows quickly and can be produced as a short rotational forest crop. Its supply can, therefore, be practically unlimited. It is very common all over India. It is cheap and above all it is very strong. Engineers have been thinking of using it in place of steel for reinforcement of cement concrete construction and enquiries are often being received at the Forest Research Institute for reliable strength data on bamboo. In view of the growing interest in the strength of bamboo, tests on scientific lines were undertaken by the Timber Mechanics Branch to investigate the influence of seasoning, age, position of the node and position along the culm, etc., on the strength of the bamboo specimens.

To begin with, tests were done on Indian bamboo of the species of *Dendrocalamus strictus* which is the most common bamboo in India. Material for tests for this experiment was obtained from the New Forest area and a factorial experiment was laid out including the following variants in the four different factors, namely (A) Seasoning – 2 groups, (B) Age – 4 different ages, (C) Disposition of nodes – 2 positions and (D) Position along culm – 3 positions. There were altogether 48 factorial combinations for each of the two strength properties studied, namely, static bending and compression parallel to grain. The total number of specimens tested was about 1,000.

The results of tests were statistically analysed and strength figures as finally determined have been given in Table 10 together with similar strength figures for other bamboos tested earlier. This publication thus fulfils a great need and places in the hands of engineers strength data that is available at present.

The help of Dr. K. R. Nair, Statistician, Forest Research Institute, and his staff in analysing the data is gratefully acknowledged.

INTRODUCTION

Bamboo is a very interesting material of construction. It is found abundantly in forests all over the country. It grows very fast. During the period of growth of the culms, a foot or more increase in height per day is common. The culm attains its full growth of 50 to 100 feet, in 2 or 3 months and matures in a short period of 2 to 4 years. The bamboo can, therefore, be produced as a short rotation forest crop and large supplies are available of it. It is cheap and above all it is very strong. It has, therefore, attracted the attention of Engineers as the combination of all these properties makes it a suitable material for constructional purposes.

CHARACTERISTICS OF BAMBOO

Bamboos belonging to a large number of species occur in Indian forests. Some are reeds of the thickness of a pencil, others grow to giant proportions. A large bamboo culm recently exhibited in Bombay was 7 inches in diameter and 106 feet long. Some bamboos have very thin walls as compared to their diameter while the wall thickness of others is as much

as ½ inch or more. Bamboos are generally hollow. But the size of the cavity depends upon soil and climatic conditions. The species *Dendrocalamus strictus*, for instance, although generally hollow, becomes practically solid in dry localities. The spacing of the nodes is also different in different species.

USES OF BAMBOO

Bamboo is used in nearly every aspect of Indian village life. In his house construction, split bamboo is used by the farmer for reinforcement of mud walls, making rafters and in roof construction. It is used for shafts of farm implements and bullock carts. It is used for foot bridges, farm fencing, rafts, basket-making, furniture, mats, hammer handles, musical instruments and a variety of other articles required by the farmer. Owing to the shortage of steel in India, the use of bamboo in place of steel for reinforcement of cement concrete construction has often been suggested and enquiries are often received at the Forest Research Institute about its strength and suitability for this purpose.

DEMAND FOR STRENGTH DATA

In view of the growing interest manifested in bamboo and the increasing demand from Engineers for reliable strength data it was decided to undertake scientific tests on some important species of bamboo available in India and to determine their strength properties. This record is the first report on such strength tests on *Dendrocalamus strictus* conducted at the Forest Research Institute. Results of similar strength tests done on other bamboo species from time to time are also presented in Table 10.

MATERIAL FOR TESTING

The species chosen for these tests was *Dendrocalamus strictus*. This is the most common species of bamboo found in Indian forests and is available in practically every State. Culms of this species were obtained from the bamboo plantations in the Silvicultural Research Demonstration Area of the Forest Research Institute. The culms were marked and cut under the personal supervision of a senior member of the Timber Testing staff with the help of the Silviculturist's staff. It should be noted that the results presented in this record relate to bamboos raised artificially in New Forest.

Fifty clumps were marked at random and one young and one old bamboo were extracted from each of them in the month of May. As bamboo begins to put forth new shoots in July–August the young bamboos of the May felling were just under 1 year age and the old bamboos were just under 2, 3, 4, etc., years of age. Bamboos 1 year and 2 year old were obtained from this felling. A similar extraction of test material was made from the same 50 clumps in the following December. The age of the new shoots in this case was just under 6 months and that of the older ones in the clump was nearly 1½ years, 2½ years, etc. One culm of ½ year and one of 2½ years were taken from the December felling.

In this way 50 bamboo culms of each of 4 age groups namely ½ year, 1 year, 2 years and 2½ years, *i.e.*, a total of 200 culms in all were obtained for testing. They ranged from 1 to 2·5 inches in diameter and 18 to 26 feet in length.

LAY-OUT OF THE EXPERIMENT

On receipt of the bamboo culms at the Testing Laboratory, each of them was critically examined and crooked, cracked or defective bamboos were weeded out leaving 40 to 44 numbers in each age group. These were then matched into pairs according to diameter, thickness of wall,

length of culm and length of internode. One bamboo of each pair was tested in the green condition and the other was tested after kiln drying to as near 12% moisture content as possible. There were thus 20 to 22 bamboos for green tests in each age group and a similar number for tests in the kiln seasoned condition.

FACTORS AFFECTING STRENGTH

The following 4 factors were deliberately introduced in this investigation to study their effect on the strength of bamboos :—

(*a*) *Seasoning*—For this purpose all the bamboos were matched into pairs and one of each pair was tested green as received in the Laboratory and the other after kiln seasoning to about 12% moisture content.

(*b*) *Age*—For this purpose bamboos of 4 age groups, namely, ½ year, 1 year, 2 years and 2½ years were chosen for testing.

(*c*) *Disposition of Nodes in a Test Piece*—For this purpose bamboos were again matched in pairs and test specimens from one of each pair were cut so as to bring a node in the centre of the test specimen at the point of loading and maximum bending moment. From the other, test specimens were cut so as to bring the central loading point between two nodes. The two positions were called (1) "Node in centre" and (2) "Centre inter node". See Figs. 1 and 2 on page 561.

(*d*) *Position along the height of culm*—For this purpose test specimens were taken from 3 positions on each culm, namely, bottom, middle and top.

The total number of treatment combinations of the 4 factors in the lay-out of this experiment, therefore, works out to $2 \times 4 \times 2 \times 3 = 48$. With 10 replications in each case, the number of test specimens required for the determination of any one strength property was 480. For the two properties, namely, static bending and compression parallel to grain the total number of tests was, therefore, 960.

TESTING

The following physical and mechanical properties were determined :—

Physical Properties

1. Moisture content.
2. Specific gravity.
3. Shrinkage.

Mechanical Properties

4. Static Bending.
    Fibre stress at elastic limit.
    Modulus of rupture.
    Modulus of elasticity.
5. Compression Parallel to Grain.
    Maximum crushing strength.

Moisture content and specific gravity were determined for every test specimen. Shrinkage was determined for 10 specimens in each age group. Shrinkage in the outside

diameter and shrinkage of the wall thickness were observed. Shrinkage in length was also measured.

One static bending and one compression test were made for each culm from each of three positions, namely, bottom, middle and top. Half the number of culms was used for "Node in centre" tests and the other half for "Centre inter node", tests. Static bending tests were made on specimens of 28 inch span with central loading in the usual manner. The specimens for compression parallel to grain were 6 inches long. Those for "Centre inter node", in this case were free from any node.

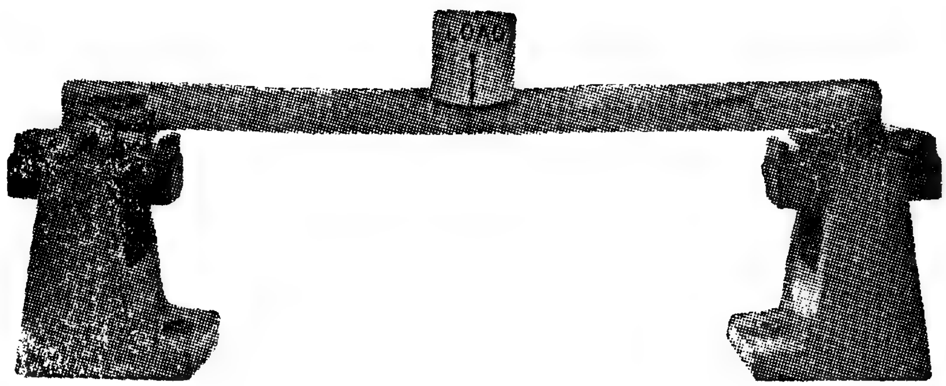

FIG. 1.—"Node in centre".

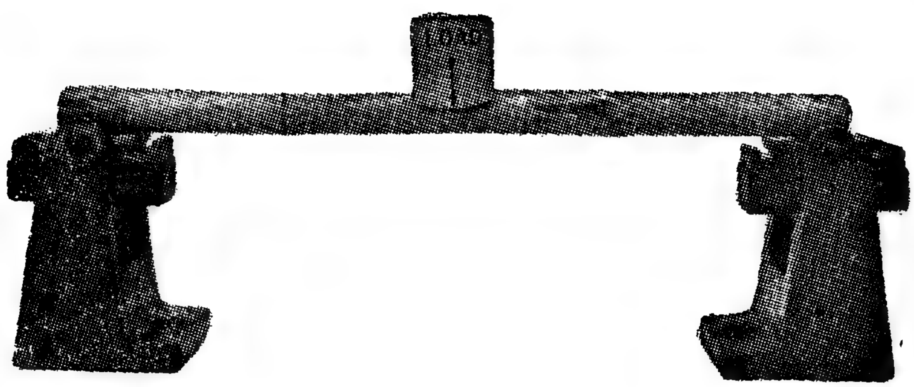

FIG. 2.—"Centre inter node".

RESULTS OF TESTS

Table 1 gives the complete results of tests of this experiment in the green condition and Table 2 those in the kiln dry condition. Table 3 shows the values of variance for the different sources of variation in the green condition for the 24 green combinations. Analysis of the 24 combinations in the kiln dry condition was not done as the moisture content was not uniform for all the combinations. (See also page 570).

TABLE 1.—*Strength*

Species.—*Dendrocalamus*

Age	Seasoning	Position in the culm	Shrinkage % green to oven-dry			Node in centre					
						Static Bending					
			Length	Dia.	Thick-ness of wall	No. of tests	Mois-ture %	Sp. Gr. dry	F.S. at E.L. lb./sq. inch	M. of R. lb./sq. inch	M. of E. 1,000 lb./sq. inch
½ yr.	Green	Bottom	..	..	..	11	111·3	·491	4,400	8,100	1,310
		Middle..	0·2	11·6	15·7	11	112·2	·469	4,400	7,900	1,450
		Top ..	..	..	..	11	105·8	·473	4,200	8,200	1,780
		Sp. Avg.	..	..	..	33	109·7	·477	4,300	8,100	1,510
1 yr.	Green	Bottom	..	..	..	9	49·4	·545	4,700	8,000	1,050
		Middle..	0·1	8·4	9·9	9	60·9	·493	4,100	7,800	1,320
		Top ..	..	..	..	9	55·9	·487	4,800	8,400	1,640
		Sp. Avg.	..	..	..	27	55·4	·508	4,500	8,100	1,310
2 yrs.	Green	Bottom	..	..	..	10	50·5	·593	6,400	10,800	1,450
		Middle..	0·1	7·0	11·4	10	52·2	·616	5,600	10,700	1,760
		Top ..	..	..	..	10	48·9	·616	5,500	10,100	1,810
		Sp. Avg.	..	..	..	30	50·5	·608	5,900	10,500	1,660
2½ yrs.	Green	Bottom	..	..	..	11	61·0	·622	8,200	15,300	1,910
		Middle..	0·1	6·7	8·8	11	55·4	·676	8,500	14,300	1,980
		Top ..	..	..	..	11	55·7	·701	9,100	14,800	2,530
		Sp. Avg.	..	..	..	33	57·4	·666	8,600	14,800	2,140

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NODE IN CENTRE			CENTRE INTER NODE								
Compression parallel			*Static Bending*						*Compression parallel*		
No. of tests	Moisture %	Max. Cr. Str. lb./sq. inch	No. of tests	Moisture %	Sp. Gr. dry	F.S. at E.L. lb./sq. inch	M. of R. lb./sq. inch	M. of E. 10.000 lb./sq. inch	No. of tests	Moisture %	Max. Cr. Str. lb./sq. inch
11	112·5	3,150	11	112·9	·522	5,000	8,600	1,710	11	111·2	3,400
11	92·3	3,450	11	110·7	·492	3,600	6,300	1,520	11	101·9	3,400
11	86·6	3,600	11	101·2	·475	3,900	6,400	1,920	11	104·4	3,400
33	97·1	3,400	33	108·3	·496	4,200	7,100	1,700	33	106·1	3,400
9	73·0	3,650	9	50·5	·535	4,400	8,900	1,310	9	88·9	3,700
9	78·8	3,650	9	71·0	·530	3,600	7,200	1,390	9	94·8	3,650
9	70·1	3,600	9	71·0	·501	5,000	7,200	1,490	9	95·2	3,700
27	74·0	3,650	27	64·2	·522	4,200	7,800	1,380	27	93·0	3,700
10	60·1	5,250	10	47·6	·628	6,900	11,400	1,610	10	66·0	5,000
10	51·8	5,150	10	47·9	·671	4,700	9,900	2,170	10	57·3	5,300
10	43·9	5,100	10	44·7	·688	6,600	10,000	2,260	10	51·2	5,250
30	51·9	5,150	30	46·7	·662	6,000	10,400	2,000	30	58·2	5,150
11	73·3	5,850	11	62·0	·629	7,200	13,300	2,100	11	62·2	5,650
11	61·2	6,550	11	57·0	·665	7,100	12,300	2,150	11	61·7	5,700
11	58·4	6,450	11	54·2	·670	6,600	11,500	2,660	11	59·9	5,650
33	64·3	6,300	33	57·7	·655	7,000	12,400	2,290	33	61·4	5,650

TABLE 2.—*Strength*

Species.—*Dendrocalamus*

Age	Seasoning	Position in the culm	Node in centre					
			Static Bending					
			No. of tests	Moisture %	Sp. Gr. dry	F.S. at S.L. lb./sq. inch	M. of R. lb./sq. inch	M. of E. 1,000 lb./sq. inch
½ yr.	Kiln dry	Bottom ..	11	8·7	·675	10,800	18,200	2,040
		Middle ..	11	8·6	·687	10,400	18,000	2,200
		Top ..	11	8·3	·702	10,300	17,700	2,660
		Sp. Avg. ..	33	8·5	·688	10,500	18,000	2,300
Sp. Avg. adjusted to 12% moisture content ..			..	12·0	..	..	*14,100*	*1,990*
1 yr.	Kiln dry	Bottom ..	9	16·8	·692	6,400	11,700	1,350
		Middle ..	9	14·6	·701	7,400	12,300	1,560
		Top ..	9	15·4	·671	7,300	12,100	1,910
		Sp. Avg. ..	27	15·6	·688	7,000	12,000	1,600
Sp. Avg. adjusted to 12% moisture content ..			..	12·0	..	..	*16,000*	*1,880*
2 yrs.	Kiln dry	Bottom ..	10	12·5	·792	9,000	16,500	1,620
		Middle ..	10	9·7	·832	11,100	17,500	2,010
		Top ..	10	8·5	·789	9,000	15,600	2,120
		Sp. Avg. ..	30	10·2	·805	9,800	16,500	1,930
Sp. Avg. adjusted to 12% moisture content ..			..	12·0	..	..	*15,200*	*1,880*
2½ yrs.	Kiln dry	Bottom ..	11	10·0	·697	11,800	21,400	1,980
		Middle ..	11	9·3	·753	13,800	22,200	2,440
		Top ..	11	8·2	·780	14,400	23,000	2,950
		Sp. Avg. ..	33	9·2	·743	13,300	22,200	2,450
Sp. Avg. adjusted to 12% moisture content ..			..	12·0	..	..	*20,000*	*2,370*

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NODE IN CENTRE			CENTRE INTER NODE								
Compression parallel			Static Bending						Compression parallel		
No. of tests	Moisture %	Max. Cr. Str. lb./sq. inch	No. of tests	Moisture %	Sp. Gr. dry	F.S. at E.L. lb./sq. inch	M. of R. lb./sq. inch	M. of E. 10,000 lb./sq. inch	No. of tests	Moisture %	Max. Cr. Str. lb./sq. inch
11	8·9	7,500	11	10·0	·695	8,600	15,700	2,430	11	9·0	8,150
11	8·9	7,950	11	9·4	·722	8,500	13,400	2,400	11	8·8	7,800
11	9·1	8,150	11	9·5	·692	7,900	11,800	2,380	11	8·4	7,800
33	9·0	7,900	33	9·6	·703	8,300	13,600	2,400	33	8·8	7,900
..	12·0	*6,250*	..	12·0	..	..	*11,700*	*2,220*	..	12·0	*6,200*
9	12·7	6,550	9	15·6	·690	7,100	12,400	1,880	9	12·4	6,550
9	12·0	6,900	9	14·6	·678	5,400	10,500	2,130	9	11·8	7,050
9	12·3	6,650	9	13·7	·634	6,500	10,300	2,000	9	11·8	6,450
27	12·3	6,700	27	14·7	·667	6,300	11,100	2,000	27	12·0	6,700
..	12·0	*6,700*	..	12·0	..	..	*13,300*	*2,410*	..	12·0	*6,700*
10	9·3	8,400	10	13·5	·785	8,700	18,200	2,090	10	10·5	7,950
10	9·1	7,900	10	12·2	·792	8,700	16,200	2,520	10	10·4	8,450
10	8·2	7,450	10	11·3	·806	9,600	16,200	2,900	10	12·6	7,700
30	8·9	7,950	30	12·3	·794	9,000	16,800	2,510	30	11·2	8,000
..	12·0	*7,050*	..	12·0	..	..	*16,800*	*2,510*	..	12·0	*7,700*
11	8·9	9,650	11	10·3	·748	11,900	20,800	2,750	11	9·2	10,000
11	8·8	10,400	11	9·8	·766	11,900	18,000	2,810	11	9·0	10,800
11	8·7	10,250	11	9·6	·796	12,500	18,000	3,110	11	9·0	10,850
33	8·8	10,100	33	9·9	·771	12,100	18,900	2,890	33	9·0	10,550
..	12·0	*8,800*	..	12·0	..	..	*17,200*	*2,760*	..	12·0	*8,900*

TABLE 3.—*Values of Variances+ for the different sources of variation in Green Specimens*

Source of Variation	D.F.	Static Bending		Compression Parallel to grain
		M. of R. in 100 lb./sq. in.	M. of E. in 10,000 lb./sq. in.	Max. Cr. Str. in 50 lb,/sq. in.
B. Between ages	3	4616·9***	7921·6***	3612·11***
C. Centre inter node ver. Node in cetre	1	551·0*	2223·4*	42·67
B × C	3	172·3	206·4	58·33
Error (1)	..	85·28 (df = 74)	449·53 (df = 72)	59·93 (df = 74)
D. Between position along culm..	2	263·6***	4253·2***	24·15*
B × D	6	5·0	313·2*	8·23
C × D	2	143·05***	62·0	7·04
B × C × D	6	15·8	143·8	15·04
Error (2)	..	15·28 (df = 147)	141·27 (df = 122)	7·33 (df = 141)

+ Variances for M. of R. and Max. Crushing stress are based on the means of ten specimen (i.e., $\delta^2/10$) and those for M. of E. are on the means of nine specimen (i.e., $\delta^2/9$).

* Denotes significantly larger than the respective error variances at 5% level of probability.

*** Denotes significantly larger than the respective error variances at 0·1% level of probability.

ANALYSIS OF TEST RESULTS AND THEIR INTERPRETATION

As already stated, the four factors affecting strength of bamboo introduced in this experiment were (*a*) Seasoning, (*b*) Age, (*c*) Disposition of nodes and (*d*) Position along culm. All combinations of the variants of these four factors have been included in the experiment giving 48 different treatments. The data for the green specimens have been analysed in Table 3. The number of replicated tests for each treatment was intended to be 10 but varied from 9 to 11. For convenience, the factorial analysis of variance as given in Table 3 was, therefore, made on the assumption of 10 replications in each case. As the actual number was 10 for half of the factors and varied only slightly between 9 and 11 for the remaining half, this assumption was justified.

The properties of modulus of rupture, modulus of elasticity and maximum crushing stress have been statistically analysed. It is seen that practically all the primary (main) effects are significant in both static bending and compression. Most of the interactions are not significant.

DISPOSITION OF NODES

Let us first consider the disposition of nodes. A node is the thickening of bamboo at regular intervals along its length. The walls are thicker on both sides of the node. There is also a cross wall at the node closing the whole inside circumference and completely separating the hollow cavity below from that above. The nodes and the cross walls seem to have been introduced by nature to stiffen the bamboo culm and prevent it from buckling and collapsing.

The disposition of the node in the test specimen was, therefore, expected to affect the strength to some extent. This factor was introduced in the lay-out to study its effect by testing half the number of specimens with a node in the centre at the loading point in the static bending test and the other half of the specimens were so cut as to bring the central loading point between two nodes, i.e., centre inter node.

From Table 3, *it is seen that the main effects for the disposition of nodes are significant* in the case of static bending but not significant in the case of maximum crushing stress. Table 4 shows the mean strengths for both dispositions of nodes for the three strength properties. "Node in centre" specimens show a higher modulus of rupture than "centre inter node" specimens as expected, but the latter are stiffer. The difference in compression is negligible.

TABLE 4.—*Mean values of the three strength functions for the two positions of nodes*

Position of node	M. of R. in 100 lb./sq. in.	M. of E. in 10,000 lb./sq. in.	Max. crushing stress in 50 lb./sq. in.
Node in centre ..	104	167	92
Centre inter node ..	94	186	90
Standard error ..	2·7	6·1	2·2

The value of modulus of elasticity for test specimens in the case of centre inter node is higher than that of node in centre. The modulus of elasticity in the former case seems to have been influenced by the stiffening effect of the nodes on either sides of the load point. The difference in modulus of rupture and modulus of elasticity, is, however, not of a high order and that in compression is negligible. In actual practice, it cannot always be possible to place a bamboo so as to bring the load at particular points only. The disposition of nodes is, therefore, the least important of the 4 factors from a practical point of view.

POSITION OF SPECIMEN ALONG THE CULM

Considering next the position of specimens along the culm, it will be seen from Table 3 that the main effect between the three positions (D) is significant in all cases. But the interactions between ages and positions (B × D) are not significant for modulus of rupture and compression and the interactions between the disposition of nodes and positions along culm (C × D) are not significant for modulus of elasticity and compression.

TABLE 5.—*Mean strength for different positions along the culm in the green condition*

Properties	Bottom	Middle	Top	Standard error
M. of R. in 100 lb./sq. in. ..	106	95	96	1·4
M. of E. in 10,000 lb./sq. in. ..	156	172	201	4·2
Max. crushing stress in 50 lb./sq. in.	89	92	92	1·0

The bottom position is significantly stronger in modulus of rupture than both the top and middle. This is due to the greater wall thickness of the culm near the ground. There is practically very little difference in compression for the 3 positions.

Modulus of elasticity is, however, seen to have a lower value for the bottom position. This seems rather contrary to general belief and cannot at present be explained. It requires further investigation.

The discussion on the disposition of nodes and the position of specimens along the culm has an academic interest only. The Engineer is generally interested to know a fairly average value for the whole culm as such that can be used in design as loads cannot always be concentrated at particular points. It is, therefore, convenient to take the average strengths from the 2 dispositions of nodes and 3 positions along the culm to represent single mean values of the strength of the culm. This has been done in Table 10 which gives the strengths of various bamboo species.

TABLE 6.—*Mean values of the three strength functions for the disposition of nodes and positions along culm in the green condition*

Position of nodes	M. of R. in100 lb./sq. in.			M. of E. in 10,000 lb./sq. in.			Max. crushing stress in 50 lb./sq. in.		
	Position along culm			Position along culm			Position along culm		
	Bottom	Middle	Top	Bottom	Middle	Top	Bottom	Middle	Top
Node in centre ..	106	102	104	143	163	194	89	94	94
Centre inter node ..	106	89	88	168	181	208	89	90	90
Standard error for each Column ..	3·1			7·8			2·5		

A reference to Table 6 shows that the lowest modulus of rupture is given by the centre inter node specimens from about the middle of the culm while the lowest modulus of elasticity is given by the node in centre specimens from the bottom position. If this fact is substantiated in further tests on bamboo, it would be possible to obtain the minimum strength of bamboo by testing only a centre inter node specimen from the middle of a culm and making adjustment for modulus of elasticity.

EFFECT OF AGE ON STRENGTH

The effect of the age of bamboo on its strength is clearly shown in Tables 7 and 8. The values given show average strengths of bamboo culms in static bending and compression for 4 age groups.

TABLE 7.—*Strength of bamboo (green) for different ages*

Age in years	M. of R. in 100 lb./sq. in.	M. of E. in 10,000 lb./sq. in.	Max. crushing stress in 50 lb./sq. in.
½	76	161	68
1	79	134	73
2	105	183	103
2½	136	222	120
Standard error ..	3·8	8·7	3·2
% Improvement in strength of 2½ yr. culms over ½ yr. culm	79	38	76

As already stated, four age groups were introduced in the experiment. The average strength in the green condition of bamboo culms of each age group is given in the above table for three strength functions, namely, modulus of rupture in bending, modulus of elasticity in bending and maximum crushing stress in compression parallel to grain. The increment in strength at 2½ years over that at ½ year is 79% in modulus of rupture 38% in modulus of elasticity and 76% in maximum crushing stress. There is seen to be practically no difference in the strengths of ½ year and 1 year culms except in modulus of elasticity which is higher for ½ year culms. About 33% improvement is seen to have taken place in modulus of rupture during the 2nd year and another 30% during the following six months only, *i.e.*, from 2 to 2½ years. It was a pity further age groups were not included in the experiment owing to the general belief that a bamboo matures in about 3 years. It, however, appears from other available strength data that further improvement, if any, may not be very great. This point, however, requires further investigation.

TABLE 8.—*Strength of bamboo (kiln dry) for different ages. Average values are roughly adjusted to 12% moisture content in each case for ease of comparison*

Age in years	M. of R. in 100 lb./sq. in.	M. of E. in 10,000 lb./sq. in.	Max. crushing stress in 50 lb./sq. in.
½	129	211	125
1	146	214	134
2	160	220	147
2½	186	256	177
% Improvement in strength of 2½ year culms over ½ year culm	44	21	42

The average strength of bamboo in the kiln dry state shows the same general trend as in the green condition. The improvement of the 2½ year culms over that of ½ year in the kiln dry state is seen to be about half as much as that in the case of green. As the culms for green and kiln dry tests were matched carefully, this reduction in improvement due to age in the case of kiln dried culms seems partially due to degrade in the process of kiln drying as many specimens were seen to have developed cracks, and partially due to the great improvement of ½ year culms in seasoning (see Table 9). All values in this case have been approximately adjusted to 12% moisture content for ease of comparison (see below).

IMPROVEMENT DUE TO SEASONING

In order to assess the improvement due to seasoning it is necessary to dry the various groups to the same moisture content. The actual moisture content at test of kiln dry bamboos varied from 9 to 15% (see Table 2). The group values in Table 2 have, therefore, been adjusted to a uniform moisture content of 12% for proper comparison. A formula for the adjustment of moisture for bamboo is being developed. In the absence of such a formula, the log formula employed for moisture adjustment for timber is used as the second best choice as otherwise comparison would not have been possible. Table 9 shows the improvement in the case of the three strength functions after adjustment.

The improvement due to seasoning in the case of ½ year and 1 year old bamboo for modulus of rupture and compression is very large. It gradually diminishes in each age group until in the case of 2½ year old culms, the improvement is about the same as for wood as is evident from the last two lines in Table 9. In young culms such as those of ½ year and 1 year age, the moisture content is excessive and may be as much as 100 to 175 per cent. As the moisture decreases with advancing age in the green state, the bamboo walls become more and more compact as can be seen by the increasing specific gravity which is 0·487 for ½ year culms and 0·661 for 2½ year culms. This effect is still more evident in kiln dry samples where the specific gravity of the kiln dry ½ year culms has become even more than that of 2½ year green culms showing the great compacting and hardening effect due to heat and loss of moisture.

One fact, however, is very remarkable. There is very little difference in the values of modulus of rupture and maximum crushing stress for ½ year and 1 year culms.

It is possible that there may be very little lignification during the first year. This may explain the similarity of strength of ½ year and 1 year old culms. Strength then begins to increase as lignification proceeds. The progress of lignification requires to be investigated to correlate the strength with the degree of lignification. This is being done as lignification will also have a great influence on the pulping properties of bamboo. (See page 571).

TENSILE STRENGTH OF BAMBOO

Tensile strength of bamboo is found by testing small thin strips of split bamboo and is an extremely variable quantity. Tests done separately showed the strength to vary from 10,000 to 50,000 lb. per square inch. These figures cannot, however, be utilized in practical work as bamboo will fail by shear long before its full tensile stress is developed. It is, therefore, customary to take the modulus of rupture and the modulus of elasticity in static bending to represent the most reliable estimate of the tensile strength for all practical purposes.

TABLE 9.—*Improvement in Strength due to Seasoning*

Species.—*Dendrocalamus strictus* from New Forest

Age of bamboo	Moisture content of green %	Specific gravity based on weight oven-dry, Vol. at test			M. of R. in lb./sq. in.			M. of E. in 1,000 lb./sq. in.			Max. Crushing stress in lb./sq. in.		
		Green	Dry	% Improvement	Green	Seasoned 12% moisture content	% Improvement	Green	Seasoned 12% moisture content	% Improvement	Green	Seasoned 12% moisture content	% Improvement
½ yr.	110	0·487	0·696	43	7,600	12,900	70	1,610	2,110	31	3,400	6,250	84
1 yr.	60	0·515	0·678	32	7,900	14,600	84	1,340	2,140	60	3,650	6,700	83
2 yrs.	49	0·635	0·800	26	10,500	16,000	53	1,830	2,200	20	5,150	7,350	43
2½ yrs.	58	0·661	0·757	15	13,600	18,600	37	2,220	2,560	16	6,000	8,850	48
Teak	52	0·598	0·611	2	11,400	15,100	32	1,670	1,880	12	5,850	8,800	50
Sal	60	0·729	0·778	7	13,600	18,700	37	1,960	2,300	17	7,050	9,100	30

SHRINKAGE

Shrinkage was determined for both the diameter and wall thickness. Young bamboo showed excessive shrinkage (see Table 1). Shrinkage of ½ year old bamboo was 11·6% in diameter and 15·7% in wall thickness from green to oven-dry, i.e., from about 100% to 0% moisture and progressively reduced to 6·7% and 8·8% respectively in bamboos of 2½ year age. Shrinkage in length was negligible being only 0·1%.

STRENGTH OF DENDROCALAMUS STRICTUS, BAMBOO

As a result of this investigation, it is now possible to place in the hands of Engineers up-to-date strength figures for the most common Indian species of bamboo namely :—*Dendrocalamus strictus*. Although these figures are for bamboo from one locality, they can be used in the same way in design as the strength figures for timbers. Strength of 2½ year old bamboo in the green state is taken as the basis. These figures may have to be modified slightly in future as a result of testing further age groups or testing bamboo from other localities. If anything, the strength figures may improve as a result of further testing.

Table 10 shows the strength of 2½ year old bamboo together with the strengths of other bamboos tested here earlier. (See page 573).

The strengths of teak and sal timbers are also given for comparison. The safe working stresses in Table 11 are obtained by dividing the ultimate stress in the green condition of 2½ year bamboo by safety factors in the usual way. (See page 574).

CONCLUSIONS

1. Specimens with a node in centre at the loading point showed a higher strength but a lower stiffness in static bending than those having the loading point between two nodes. In compression parallel to grain, the difference in strength due to the disposition of nodes is not significant.

2. The difference in the strength of specimens from different positions along the culm is significant in all properties. In static bending, specimens from bottom positions near the ground are stronger than those from middle and top, but are lower in stiffness. There is practically no difference in compression for the three positions.

3. The study of the disposition of nodes and positions along the culm is of an academic interest only. In practice the average strength of the whole culm is used for design.

4. There is practically no difference between the strengths of ½ year and 1 year old bamboos. They seem to be still growing and establishing themselves up to the end of first growing season. Then the bamboos begin to gain in strength as the lignification proceeds. The increase in strength during the second year is about 33%, and during the next half-year only it is another 30%. The progress of lignification requires to be investigated to correlate the increase in strength with the degree of lignification. This is being studied as it will also have a great influence on the pulping properties of bamboo.

5. Seasoning of mature bamboos increases the strength by about 40 to 50%. There is a great improvement in strength in the case of very young bamboos due to seasoning. As young bamboos have too much moisture, the loss of moisture and excessive shrinkage seem to have a great compacting effect on young bamboos than on old ones which have comparatively less moisture.

6. The age at which bamboos attain mechanical maturity seems to be more than 2½ years and requires to be determined in a further experiment by taking more age groups.

TABLE 10.—*Strength of Bamboo*

Species	Locality	Age	Seasoning	Moisture per cent	Sp. Gravity based on weight over dry & Vol. at test	Dia. of bamboo inch	Thickness of wall of bamboo inch	Shrinkage % Green to oven dry: Length	Shrinkage % Green to oven dry: Dia.	Shrinkage % Green to oven dry: Thickness of wall	M. of R. in lb./sq. inch	M. of E. in 1,000 lb./sq. inch	Max. crushing stress in lb./sq. inch	Remarks
Dendrocalamus strictus	New Forest, Dhera Dun	2½ yrs.	Green	58	0·661	1·48	0·39	0·1	6·7	8·8	13,600	2,220	6,000	Strength of 2½ yr. old bamboo given ; strength may increase slightly in older culms.
Dendrocalamus strictus	New Forest, Dehra Dun	..	Kiln dry	12	0·757	1·37	0·35	..	..	..	18,600	2,560	8,850	
Dendrocalamus strictus solid lance staves	Dehra Dun	..	Dry	13	..	0·98	0·37	..	..	..	17,000	2,620	.	
Tent pole bamboo probably *Bambusa balcooa*	U.P.	Age not known	Dry	22	..	2·56	0·48	..	..	..	14,400	2,420	6,400	
Bambusa balcooa	U.P.	..	Green	42	0·783	2·44	0·51	..	..	..	9,300	1,040	6,650	
Bambusa nutans, *makla* bamboo	Buxa Div., Bengal	..	Dry	12	..	2·39	0·36	..	..	..	9,400	1,580	..	
Bambusa tulda, *jatha* bamboo	,,	..	,,	12	..	2·00	0·34	..	..	..	12,500	1,750	..	
Tectona grandis, teak	Burma and Malabar	..	Green	52	0·598	..	..		Rad'l 2·3	Tang'l 4·2	11,400	1,670	5,850	Given for comparison.
,,	,,		Air-dry	12	0·611	..	..		..	..	15,100	1,880	8,800	..
Shorea robusta, sal	U.P., Bengal and Assam	..	Green	60	0·729	..	..		4·3	9·2	13,600	1,960	7,050	,,
,,	,,	..	Air-dry	12	0·778	..	..		..	..	18,700	2,300	9,100	,,

TABLE 11.—*Safe working stresses of Dendrocalamus strictus*

Species	Locality	Age	Weight in lb. at 12% m.c.	ALL GRADES	SAFE WORKING STRESS IN LB./SQ. IN.						Remarks
				Modulus of Elasticity in 1,000 lb./sq. in. All locations	Bending and tension along grain			Compression parallel to grain			
					Inside location	Outside location	Wet location	Inside location	Outside location	Wet location	
Dendrocalamus strictus, bamboo	New Forest, Dehra Dun	2½ yrs.	0·42 lb. per foot	2,220	2,250	1,950	1,600	1,500	1,350	1,100	
Tectona grandis, teak ..	Burma and Malabar	..	43 lb. per cu. ft.	1,600	2,300	1,950	1,550	1,500	1,300	1,100	Standard grade (structural No. 2) for comparison.
Shorea robusta, sal ..	U.P., Bengal and Assam	..	54 lb. per cu. ft.	1,960	2,700	2,250	1,800	1,750	1,550	1,300	,,

APPENDIX

THE USE OF BAMBOO AS REINFORCEMENT FOR CEMENT CONCRETE CONSTRUCTION

The idea of making use of bamboo as reinforcement for cement concrete has been attracting the attention of Engineers for the last 25 years. The shortage of steel after the last war has revived the interest in this subject very greatly and enquiries are often being received at the Forest Research Institute on the strength and suitability of bamboo for reinforcement. The obvious advantages of bamboo are (1) Its plentiful supply, (2) Its rapid growth so that a sustained annual supply can be maintained, (3) Its availability in almost all States and (4) Its relative cheapness.

There are, however, many practical difficulties in the use of bamboo. In the first place, the species of bamboo must be carefully selected. Any bamboo will not do for this purpose. Bamboo with a thick wall having a large proportion of the outer hard portion is necessary. Small solid bamboo will be very useful. These considerations limit its availability. The bamboo should be free from defects and must be treated with a non-oily preservative. It must further be chemically treated to stabilize its dimensions and prevent excessive swelling and shrinkage so that the bond between bamboo and cement may be maintained. This is a costly process.

The strength of bamboo depends upon several factors, such as the species, the thickness of walls, the spacing of nodes, the locality and the climatic conditions, the stage of maturity, etc. Our knowledge about the strength of bamboo is limited as only a few species have yet been tested. The *Dendrocalamus strictus* species of bamboo is found throughout India and is, therefore, an important species. Its breaking strength in the green condition, in tension and bending is about 13,500 lb./sq. in. and its modulus of elasticity is 22,00,000 lb./sq. in. Applying a factor of safety of 6, the safe working stress in tension and bending can be taken as about 2,200 lb./sq. in. Its strength in the green condition in compression parallel to the grain is about 6,000 lb./sq. in. Applying a factor of safety of 4 in this case, the safe working stress in compression can be taken as 1,500 lb./sq. in.

The most serious problem in the use of bamboo for stressed parts is, however, the space occupied by bamboo reinforcement to carry the required loading. In the case of reinforced cement concrete, the cement takes all the compressive stresses and completely covers and holds fast to the reinforcement which is designed to take up all the tensile stresses. The safe working stress of even ordinary steel in tension is about 20,000 lb./sq. in. and that for bamboo is about 2,200 lb./sq. in. If bamboo is to be used in the same way as steel for reinforcement, it will require roughly 10 times the space required for steel. Beams and slabs with bamboo reinforcement will have to be of a considerably greater cross section to cover this big volume of the reinforcing material. They will, therefore, require more cement and will be heavy. Whether they would be cheap is a moot point and requires careful analysis of individual cases before adoption.

Concrete construction with bamboo reinforcement can, however, be used very effectively for unstressed parts such as partition walls and roofing slabs and in special cases such as underground air raid shelters which require very deep cement concrete ceilings.

FERNS OF NEPAL

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The kingdom of Nepal extends for five hundred miles along the Himalayas, from the western end of Sikkim to the eastern border of Kumaon. Guarding the northern side of the State, stands the world's mightiest mountain peaks, the Mount Everest (29,002 ft.) and a few other almost equally high snow covered peaks, which separate Nepal and India from the table-land of Tibet.

Although Nepal is of great interest to the botanist and the plant lover, comparatively little is known of the flora of the country. Why Nepal preferred to remain secluded from other people till only recently was due to a faith ingrained in every Nepalese. The presence, even the look, of a stranger was to them fraught with evil influence, and intrusion into the woods, hills, rivers and temples of Nepal was little less than sacrilege.

The first botanist to visit Nepal was Dr. Buchanan Hamilton ; this was in 1802. His collections were restricted to the neighbouring mountains of Kathmandu, the capital of Nepal. His plants were described by David Don in the 'Prodromus Floræ Nepalensis' published in 1822.

The next botanist to visit Nepal was the celebrated Dr. Wallich, Superintendent of the Calcutta Botanic Gardens. Wallich spent a year at Kathmandu (1820–21) and collected intensively in the valley and among the low wooded hills surrounding it. Although he was not allowed to go beyond the confines of the valley, he prevailed on pilgrims to bring him plants from the mountains surrounding the sacred lakes of Gossain Than, which lie at an altitude of 15,000 ft. and are three to four days' march north of Kathmandu. They are visited annually, by thousands of pilgrims during the months of August and September, and it is from this locality that many interesting Himalayan plants were recorded for the first time by Wallich. His plants are described in Wallich's 'Tentamen Floræ Nepalensis' (1824).

Sir Joseph Dalton Hooker, the noted traveller and author of the monumental 'Flora of British India', was the next to visit Nepal. He entered the eastern end of Nepal by special permission in 1848 but as his visit took place during the winter, the botanical results were limited by the weather experienced. An account of his entry into Nepal is contained in his 'Himalayan Journals' published in 1854.

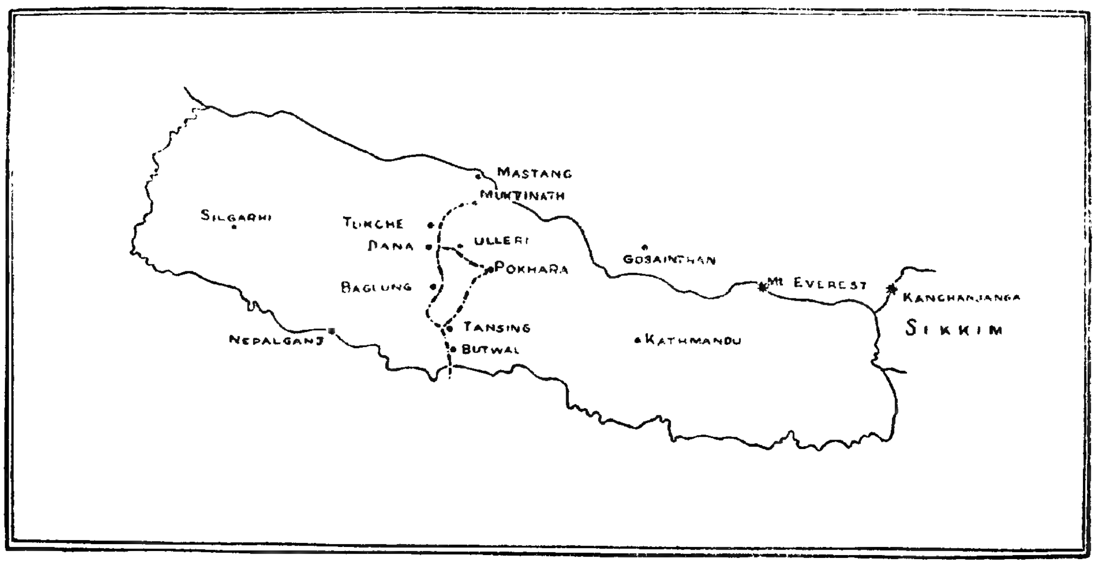
Later, in the year 1876 Dr. John Scully collected plants in Nepal and Mr. I. H. Burkill made a short journey to Nawakot, ten miles west of Kathmandu in 1907. Burkill in his 'Notes from a Journey to Nepal', published in 1910 (Rec. Bot. Surv. India, Vol. IV, No. 4) states that he and Wallich, separated by a period of eighty-seven years, gathered the same plants in the same spots.

In 1929, with the permission and co-operation of the Nepalese Government, a botanical party from the Forest Research Institute, Dehra Dun, consisting of Mr. Basant Lal Gupta and Bis Ram Collector, was sent to Nepal with the intention to collect plants in the valley of the Karnali river in the neighbourhood of Simikot. Unfortunately the leader of the party, Mr. Gupta was taken seriously ill and had to be carried back from Silgarhi. About five-hundred species were collected during this expedition. These are listed in Forest Bulletin (Botany Series) No. 76, published in 1932.

During 1927–1937, two Nepalese collectors, Maj. Lall Dhwoj and Prof. Sharma, made extensive collections in east, central and west Nepal as far as Annapurna. Their collections were mostly sent to the British Museum, Natural History, London.

An interesting illustrated account of the plants collected by Mr. O. Polunin from central Nepal during May to September, 1949 appears in the Journal of the Royal Horticultural Society, London, Vol. 75, Part 8, pp. 302–315, August, 1950.

Practically all those who collected earlier in Nepal paid little attention to the collection of ferns from that country. The present list of 'Ferns of Nepal' is exclusively based on a collection made by Dr. R. L. Fleming of the Woodstock School, Mussoorie, while engaged in an expedition to the Kali Gandak region of west Nepal, with the primary object of collecting birds, especially game birds for the Chicago Natural History Museum. Collections were made during the three winter months from November, 1949 to January, 1950. The party travelled from the *tarai* almost to the Tibetan border within a few miles of Muktinath and returned via Pokhara and Tansen, capital of west Nepal. The route taken by the party is shown in the map.



Map of Nepal showing Dr. Fleming's route - · - · - ·

Dr. Fleming in a private communication informs the senior author that it was not the best time to secure ferns and as his main job was to collect game birds, he collected ferns which he did not recognize, or only when he did not find many birds.

In conclusion it is our pleasant duty to thank Dr. R. L. Fleming for giving us an opportunity of working out his collection of ferns, and to Mr. A. H. G. Alston of the British Museum, London for kindly checking our identifications. As little is on record on the fern flora of Nepal, it is hoped that the following enumeration will be of interest. All the specimens are deposited in the Dehra Dun Herbarium.

As the synonymy of ferns presents great difficulty we have tried to follow, as far as practicable, the names accepted by C. Christensen in his Index Filicum. For the convenience of Indian workers, however, the name used by Beddome in his Forns of British India has been given as synonym.

HYMENOPHYLLACEÆ

1. *Trichomanes plicatum* (V.d.B.) Bedd.
   Lumpek, 7,000 ft., on trees at bases, Fleming 929.

2. *Hymenophyllum exsertum* Wall.
   Ulleri, 6,000 ft., on wet rocks, Fleming 907.

POLYPODIACEÆ

3. *Dryopteris nigra* Ching.
   5 mi. above Tukche, 11,500 ft., fronds grow in whorls, Fleming 889.

4. *Dryopteris odontoloma* (Moore) C. Chr. ; *Lastrea filix-mas* L. var. *odontoloma*.
   5 mi. above Tukche, 11,500 ft., in dark forest, fronds erect, Fleming 888.

5. *Dryopteris papilio* (Hope) C. Chr. ; *Nephrodium papilio* Hope.
   Andhi Khola, 18 mi. N.E. Tansing, 2,000 ft., in damp ravine with stream, Fleming 861, 862.

6. *Dryopteris sparsa* (Ham.) O. Ktze. ; *Lastrea sparsa* Don.
   13 mi. S.E. Baglung, 3,000 ft., Fleming 903 ; Tansing, 4,800 ft., in damp forest northern slope, Fleming 952.

7. *Polystichum* aff. *atkinsoni* Bedd.
   10 mi. S. Pokhara, on limestone rocks, 3,500 ft., Fleming 873.

8. *Polystichum lentum* (Don) Moore ; *P. auriculatum* L. var. *lentum* Don.
   15 mi. W. Pokhara, 6,000 ft., in shaded damp places, Fleming 867 ; Ulleri, 6,000 ft., in deep shade, Fleming 910 ; below Baglung, 2,500 ft., Fleming 922 ; Tansing, 4,800 ft., in damp forest, Fleming 951.

9. *Polystichum nepalense* (Spr.) C. Chr. ; *P. marginatum* Wall.
   13 mi. S.E. Baglung, 3,000 ft., Fleming 901 ; Ulleri 6,500 ft., in shade, Fleming 906.

10. *Polystichum neo-lobatum* Nakai.
    5 mi. above Tukche, 11,500 ft., on dark conifer forest floor, Fleming 886.

11. *Polystichum nigropaleaceum* (Christ.) Diels ; *P. aculeatum* Sw. var.
    5 mi. above Tukche, 11,500 ft., in heavy forest, Fleming 890 ; Ulleri, 6,000 ft., Fleming 913.

12. *Polystichum obliquum* (Don) Moore ; *P. auriculatum* L. var. *cæspitosum* Wall.
    5 mi. N. Riri Bazaar, 2,200 ft., Fleming 938.

13. *Polystichum stimulans* Presl. ; *P. ilicifolium* Don.
    Ulleri, 6,000 ft., under rocks, Fleming 914.

14. *Polystichum thomsoni* (Hk. f.) Bedd.
    Lumpek, 7,000 ft., in wet forest on rocks, Fleming 880 ; above Dana, 11,000 ft., between rocks in dark forest, Fleming 884 ; Ulleri, 6,000 ft., Fleming 908 ; Lumpek, 7,000 ft., on wet rock, Fleming 933.

15. *Oleandra wallichii* (Hk.) Presl.
Andhi Khola, 20 mi. N.E. Tansing, 2,000 ft., growing in shady limestone crevices, Fleming 860 ; 14 mi. N. Riri Bazaar, 2,200 ft., on trees, Fleming 895 ; below Baglung, 2,500 ft., on rocks, Fleming 920.

16. *Nephrolepis cordifolia* (L.) Pr.
5 mi. N. Riri Bazaar, 2,200 ft., in wet forests, common, Fleming 892.

17. *Microlepia speluncæ* (L.) Moore.
Andhi Khola, 2,200 ft., 23 mi. N.E. Tansing along road among rocks, rhizomes rubbery, easy to pull up, Fleming 863.

18. *Stenoloma chusanum* (L.) Ching ; *Stenoloma chinensis* Sw.
15 mi. west of Pokhara, 6,000 ft., along road on banks, Fleming 866 ; 14 mi. N. Riri Bazaar, 2,200 ft., on exposed banks, Fleming 893 ; 13 mi. S.E. Baglung, 3,000 ft., on exposed banks, Fleming 905 ; below Baglung 2,500 ft., on open banks, Fleming 915.

19. *Lindsaya cultrata* (Willd.) Sw.
2,000 ft., colony under overhanging rock, only one seen, Fleming 864.

20. *Athyrium drepanopterum* (Kze.) A. Br.
Andhi Khola, 20 mi. N.E. Tansing, 2,000 ft., Fleming 856 ; 14 mi. N. Riri Bazaar, 2,200 ft., Fleming 894 ; 13 mi. S.E. Baglung, 3,000 ft., Fleming 904 ; 5 mi. N. Riri Bazaar, 2,200 ft., Fleming 936, 940.

21. *Athyrium foliolosum* (Wall.) Bedd. ?
Lumpek, 7,000 ft., Fleming 927.

22. *Athyrium macrocarpum* (Bl.) Bedd.
Srinagar forest, Tansing, 4,800 ft., in damp shady places, Fleming 871, 902, 953.

23. *Ceterach paucivenosum* Ching.
Ulleri, 6,000 ft., Fleming 909.

24. *Asplenium pseudofontanum* Koss. ; *A. varians* Hk. & Grev. var.
Lumpek, 7,000 ft., Fleming 932.

25. *Pityrogramma calomelanos* (L.) Link.
Below Baglung, 2,500 ft., on dry hill-sides, Fleming 916.

26. *Cheilanthes farinosa* (Forsk.) Kaulf.
5 mi. N. Riri Bazaar, 2,200 ft., along road, Fleming 935 ; 4 mi. N.W. Tansing, 3,000 ft., on rocks, Fleming 956.

27. *Cheilanthes rufa* Don.
Below Baglung, 2,500 ft., on rocks, Fleming 885 ; 8 mi. N. Butwal, 2,500 ft., on rocks, Fleming 954.

28. *Onychium siliculosum* (Desv.) C. Chr. ; *O. auratum* Klf.
Below Baglung, 2,500 ft., along road in sun, Fleming 917.

29. *Pteris biaurita* L. ; *Campteria biaurita* L.
Pokhara, 3,000 ft., growing along walls and in ground, Fleming 865 ; 15 mi. S.E. Baglung, 2,000 ft., sunny spots, Fleming 900 ; Ulleri, 6,000 ft., Fleming 911 ; 5 mi.

N. Riri Bazaar, 2,200 ft., along road, Fleming 934 ; below Tansing, 3,500 ft., in sunny places, Fleming 944.

30. *Pteris dactylina* Hk.

5 mi. above Tukche, 11,500 ft., under rocks, Fleming 891.

31. *Pteris wallichiana* Agardh. ; *Campteria wallichiana* Ag.

Lumpek, 7,000 ft., Fleming 926.

32. *Vittaria himalayensis* Ching.

Lumpek, 7,000 ft., hanging on trees, Fleming 928.

33. *Polypodium amœnum* Wall. ; *Goniophlebium amœnum* Wall.

Lumpek, 7,000 ft., on trees, Fleming 931.

34. *Polypodium contortum* Christ.

Pokhara, 3,000 ft., hanging on trees, Fleming 869 ; 5 mi. N. Riri Bazaar, 2,200 ft., Fleming 937.

35. *Polypodium* (*Lepisorus*) *loriforme* Wall. ; *Pleopeltis linearis* Thunb. (in part).

5 mi. N. Riri Bazaar, 2,200 ft., on trees, Fleming 874 ; Ulleri, 6,000 ft., on trees, Fleming 912 ; Lumpek, 7,000 ft., Fleming 930.

36. *Polypodium lucidum* Roxb. ; *P. leiorhizum* Wall. ; *P. cuspidatum* Don.

Andhi Khola, 22 mi. N.E. Tansing, 2,200 ft., on lime rocks in shade, Fleming 857 ; 5 mi. N. Tansing, 2,800 ft., on trees, Fleming 870 ; Baglung, 2,200 ft., on wet dark hill-sides, Fleming 876 ; Lumpek, 7,000 ft., on trees, Fleming 896 ; below Baglung, 2,500 ft., on ground in wet forest, Fleming 897.

37. *Polypodium nudum* (Hk.) Kze., *Pleopeltis linearis* Thunb. (in part).

5 mi. N.W. Tansing, 2,500 ft., Fleming 958.

38. *Polypodium wallichianum* Spr. ; *Pleopeltis juglandifolia* Don.

Lumpek, 7,000 ft., on trees, Fleming 925 ; 5 mi. N. Riri Bazaar, 2,200 ft., Fleming 939.

39. *Drynaria mollis* Bedd. ?

5 mi. above Tukche, 11,500 ft., on trees, fertile fronds dry, Fleming 887.

40. *Drynaria propinqua* (Wall.) J. Sm.

5 mi. N. Riri Bazaar, 2,200 ft., on trees, Fleming 875, 941 ; below Tansing, 3,500 ft., Fleming 947.

41. *Pyrrosia adnascens* (Sw.) Ching ; *Niphobolus adnascens* Sw.

Below Baglung, 2,500 ft., Fleming 919.

42. *Pyrrosia beddomeanus* (Gies.) Ching ; *Niphobolus stigmosus* Sw.

5 mi. N.W. Tansing, 2,500 ft., on rocks, Fleming 957.

43. *Pyrrosia mannii* (Gies.) Ching ; *Niphobolus fissus* Bl.

On rocks and trees, 2,200 ft., Fleming 877 ; below Tansing, 3,500 ft., Fleming 948, 949 ; 5 mi. N.W. Tansing, 2,500 ft., Fleming 959.

GLEICHENIACEÆ

44. *Gleichenia linearis* (Burm.) Clarke.
Below Tansing, 3,500 ft., in profuse colonies, Fleming 945.

SCHIZÆACEÆ

45. *Lygodium flexuosum* (L.) Sw.
Below Baglung, 2,500 ft., Fleming 918.

46. *Lygodium japonicum* (Thunb.) Sw.
Below Baglung, 2,500 ft., Fleming 921.

FERN ALLIES

47. *Lycopodium squarrosum* Forst.
Pokhara, 3,000 ft., hanging on trees, club moss, Fleming 868.

48. *Selaginella fulcrata* (Ham.) Spring.
Below Tansing, 3,500 ft., Fleming 943, 946.

49. *Selaginella pallida* (Hk. & Grev.) Spring.
In shade on banks, 3,500 ft., Fleming 872.

50. *Selaginella subdiaphana* (Wall.) Spring.
Below Tansing, 3,500 ft., Fleming 950.

A NOTE ON THE KARADA BARK TANNINS

BY P. RAMACHANDRA RAO AND S. V. PUNTAMBEKAR

Karada bark was examined as a source of commercial tannins. The air-dry bark contained 30–32 per cent of water extractives of which 65 per cent were tannins, the remaining being soluble non-tannins. 75 per cent of these tannins were found to be the red coloured phlobatannins.

Cleistanthus collinus, Benth. known as *Karada* (Hindi) or Kodarsi (Telugu) is a small tree which grows commonly in the dry hilly areas in various parts of India, particularly Orissa, Madras, Madhya Pradesh and Hyderabad. The tree is reported to be of great economic importance[1]. Its wood is very hard and is valued as timber 'especially for poles, for which purpose it is considered to be as good as teak'.

The bark was reported to contain 33·3 per cent of tannins[2], the presence of which was later corroborated by Dekker[3] who also reported the presence of a saponin and a sterol amongst the other constituents. Fraymouth and Pilgrim[4] made a detailed study of the tanning properties of the different parts of the Karada tree with the following results :—

	Tannin %
Sifted powder from leaves	18·9
Residue after sifting	13·35
Twig bark	20·6
Dried green fruit	14·4

Very recently Basu[5] has suggested the bark as a substitute for wattle and has reported the following data for the air-dry bark containing 10 per cent moisture :—

Tannins	25–42·7%
Soluble non-tannins	10·8–21·4%
Insoluble non-tannins	36·5–55·5%

It was at the request of the Forest Research Officer, Orissa, that lightening of the deep red colour of the tannin extract of the bark was undertaken. To do this it was necessary to study the nature of the tannins which were found to be mostly phlobatannins. In view of the fact that phlobatannins possess a deep red colour and are not of much value in tanning, the use of Karada bark as a substitute for wattle shows little promise. While the experiments to reduce the intensity of the red colour of the tannin extract are still in progress the results of the examination of the tannins are reported in this note.

The powdered bark (100g., moisture 8–10%) was repeatedly extracted with boiling water. The extract, which was deep red in colour, contained much colloidal and suspended matter so that filtration through fluted or even pressure filters was extremely slow. It was, therefore, filtered through a continuous centrifuge when a clear dark red solution was obtained. The extract was made up to four litres and analysed :—

Specific gravity	1·002
pH	6·3
Total solids	30–32 g.
Total tannins	20–22 g.
Colour in ½ inch cell in Lovibond tintometer..	65–70 Red units

A further examination of the extract showed that it contained a high percentage (75%) of phlobatannins with only a small amount of the depside tannins. On concentration to about a fourth of its volume and subsequent treatment with an equal quantity of saturated sodium chloride solution the extract deposited the phlobatannins as a dark red precipitate ; and quantitative estimation showed that the phlobatannins formed 75 per cent of the total tannins. The precipitated tannin went readily into solution with water and responded to the following tests characteristic of phlobatannins as described by Russel[6].

	Reagent	*Observation*
1.	Alcoholic ferric chloride	.. Bluish brown precipitate.
2.	Aqueous ferric chloride ..	.. Dark bluish brown colour and precipitate.
3.	Gelatin solution ..	.. Dirty reddish white precipitate.
4.	Lead acetate solution ..	.. Light red coloured precipitate soluble in acetic acid.
5.	Boiling dilute hydrochloric acid	.. Red precipitate even before boiling.
6.	Bromine water ..	.. Light orange precipitate.
7.	Calcium hydroxide ..	.. Dull pinkish precipitate.
8.	Sodium sulphite ..	.. Light pink colour and precipitate.
9.	Formaldehyde and hydrochloric acid	Light buff coloured flocculent precipitate.
10.	Copper sulphate and ammonia	.. Heavy dark precipitate.
11.	*Aqueous ammonia* ..	.. *Solution darkens.*
12.	Potassium dichromate solution	.. Brown precipitate.
13.	Potassium ferricyanide and ammonia	Deep orange red precipitate.
14.	Hide powder ..	.. Absorbed completely.

The phlobatannins were precipitated from aqueous extract by acidification and were also obtained by a method of direct extraction of the bark with organic solvents like acetone or alcohol.

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TIMBER DRYERS' AND PRESERVERS' ASSOCIATION OF INDIA

We have great pleasure in announcing the formation of the Timber Dryers' and Preservers' Association of India. We understand that it has the support and backing of the Government of India, Ministry of Agriculture. The proper utilization and conservation of timber is very important for helping the Industrialization of India. The Planning Commission has also stressed the imperative need of establishing a network of seasoning and preservation units in the whole country. The objects and purposes of this association as is given in its constitution are—

(*a*) To promote the use of seasoned and treated wood for all purposes of construction such as housing, railway sleepers, bridges, transmission poles, ocean going ships and country crafts, furniture, etc., for which timber is pre-eminently suitable by virtue of its special advantages, widespread availability, low cost, facility in fabrication and extended service life so as to secure not only proper and economical utilization of timber but also conservation of our forest and timber resources.

(*b*) To bring into contact producers and consumers of timber, timber technologists, timber statisticians and structural engineers of the State Governments and private organizations, interested in the use of seasoned and treated timber.

(*c*) To investigate and discover and to acquire and collect, knowledge of all kinds of methods of drying, preserving and fire-proofing of wood.

* * * *

(*g*) To train and supply technicians for the seasoning and preservation plants, and for all other operations relating to or connected with the above industries.

(*h*) To prepare and supply blue prints, estimates and organizational details for the procurement, lay-out, erection and operation of wood seasoning and preservation units.

The Association has four classes of members namely (*a*) Professional, (*b*) Commercial, (*c*) Associate and (*d*) Honorary Members, thus catering for all interests concerned. The provisional Executive Committee of the above association comprises of :—

1.	Honorary President	.. Shri M. D. Chaturvedi, I.F.S., Inspector-General of Forests, Ministry of Agriculture, Government of India, New Delhi.
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Any further information can be had from the Honorary Secretaries of the Association.

RAJPUTANA DESERT – ITS VEGETATION AND ITS SOIL

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A practical approach to the problem of immobilization of the Rajasthan Desert will be found in the recommendations of the *ad hoc* committee appointed by the Government of India[1] to study the problem. The chief problems of Rajasthan are how (1) to prevent more sand blowing into it from the West : (2) to prevent movement of sand in and from the area so that fertile agricultural fields may not be covered with sand drifts and (3) to see that the local population get their requirements of fuel and small timber. All these problems have been tackled by the *ad hoc* committee from a practical angle as a study of its recommendations will reveal.

Principal solution of the problem The solution of the problem lies in the afforestation of all available land in the desert tract and – this is still more difficult – in the protection of the existing tree growth. Afforestation of these desert sands is a very difficult task for the silviculturist ; he must rely on a careful assessment of soil and climatic factors in the prevailing critical conditions. Patches of existing good growth, especially of *Prosopis spicigera* which is practically the only indigenous species seen in many of the tracts, give clues to the possibilities of the locality. *Prosopis juliflora*, the ubiquitous exotic, is another species which has flourished and spread itself in suitable places. *Delonix alata*, has been planted successfully in some places. *Tecoma undulata* is another prominent indigenous tree in these deserts. *Nim* is reported to have been introduced along with *Albizzia lebbek* in the tract. The occurrence and growth of these species are no doubt reassuring, but to raise forests in a tract, where the rainfall is generally below ten inches, and often falls below five inches in some years will be a very difficult feat.

Early descriptions of the Rajasthan desert soils—According to the soil and geological maps of India prepared by Wadia, Krishnan and Mukerji[2] in 1935, the desert soil of Rajputana derives partly from material formed by physical disintegration of the local rock and partly from blown sand. Later, in January, 1943, the first soil map of India was prepared by Viswanath and Ukil[3] of the Indian Agricultural Research Institute, in consultation with the Silviculturist and Soil Chemist of the Forest Research Institute. On this map most of the Rajputana desert (including Bikaner, Bahawalpur, Jaisalmer and Jodhpur) is classed under coarse alluvium. The area comprising Jaipur, Ajmer-Marwara and Udaipur adjoining the Aravallis was, however, classed separately as brown sandy soil. In the revised map by Raichaudhuri[4] a large part of the former area is designated as "Desert soil" and most of the latter as "brown sandy soil". The soils of the "Rann of Cutch" fall under "Alluvial soil impregnated with varying amounts of salt". The soils of the North Kathiawar, South of the Little Rann of Cutch come under "Brown sandy soils", while those in the coastal strip south of Kathiawar along the Arabian Sea are designated coastal alluvium. Soils of the middle region of Kathiawar are classified as "medium black soil".

General topography and soil features - In February 1952, the following tracts were visited by the writers :—Jodhpur, Shergarh, Samdari, Barmer, Munabao, Raniwara, Sanchor, Bhawatra, Jaswantpura, Rewadhar, Mundar (Sirohi Gap), Mt. Abu and Jaipur. In these localities the following topographical features were observed.

I. AREAS WITH HIGH SAND DUNES FORMING RIDGES AND EXTENSIVE SAND DEPOSITS IN THE VALLEYS

In these areas it is found (i) that sand dunes and valleys are usually in a definite direction generally S.E. to N.W. (ii) that the dunes though formed of loose sand are not shifting ones and carry trees especially of *Prosopis spicigera* as well as shrubs and (iii) that the sand is calcareous. These tracts are reported to put on a green appearance with grass and shrubs even after very light showers. Excessive trampling by sheep and goats loosens the surface sand and plenty of wind erosion takes place. Munabao and Shergarh provide examples of this type of tract. Here the subsoil water-level is very low and afforestation will be rather difficult.

II. AREAS WITH HIGH SAND DUNES AS IN I BUT WHERE THERE ARE ALSO ROCKY HILLS AND RANGES

The nature of sand is calcareous as in area (I), but this sand is definitely of aeolian origin and not the product of disintegration of the local rock. The direction of the sand dunes varies according to the local wind direction which in turn depends on the local configuration of the hills. Deposits of sands are seen on the N.E., E. and other slopes of the hills. The bases of the hills are often engulfed in sand to a depth of up to hundred feet in places. On account of the occurrence of these rocky beds there is a possibility of striking water springs here and there. The sands do not shift on account of the rocks and hills of the tract and there is vegetation on them. Barmer tract is typical of this type of topography.

III. AREAS WITH STABILIZED SAND

In certain tracts, sand has become stabilized under prolonged weathering, and fertile soil has been built up by the formation, accumulation and admixture of clay and organic matter. Due to weathering and leaching, the calcium carbonate has been washed down to lower layers, leaving only a neutral or slightly alkaline soil on top and, a "Kankar" pan in the subsoil. The pH of the soil generally increases with the depth owing to increasing proportion of leached calcium. The top-soil is fairly compact and not loose sand. Where subsoil water is available, this type of tract can grow good agricultural crops as the top-soil is rich and has good depth. *Prosopis spicigera* is seen in plenty in such tracts and shrubby undergrowth is common. *Prosopis juliflora* has also been tried with considerable success in such localities. The effect of the *Kankar* pan on the development of tree roots remains to be studied.

Important plant species met with in the different types of soils.—The following is a fairly representative list of the plants found in the tracts described above. This list may help in the preliminary selection of species for afforestation.

1. EARLY COLONIZERS

I. *On fresh sand*

Shrubs.—*Calotropis procera* (c), *Crotalaria burhia* (c), *Aerua tomentosa* (c), *Citrullus colocynthis* (f), *Leptadenia spartium* (c), *Indigofera argentea* (c) locally.

Grasses.—*Panicum turgidum* (f), *Eleusine flagellifera*.

II. *On salty soils*

Haloxylon recurvum (c)
Suæda, spp.

2. FIXED SANDS

(*a*) Trees	*Prosopis spicigera* (c)
	Acacia senegal (f)
	Tecoma undulata (c)
	Acacia arabica (Clayey soils and near water spreads)
	Azadirachta indica } introduced
	Albizzia lebbek } introduced
(*b*) Small trees	*Salvadora oleoides* (c)
	Capparis aphylla (c)
	Acacia jacquemontii (f)
	Acacia leucophlœa (o)
	Balanites roxburghii (o)
(*c*) Shrubs	*Aerua tomentosa* (f)
	Zizyphus rotundifolia (f)
	Crotalaria burhia (f)
	Calligonum polygonoides (f)
	Lycium barbarum (f)
	Calotropis procera (f)
	Leptadenia spartium (f)
	Indigofera, spp. (f)
	Clerodendron phlomoides (f)
	Cassia auriculata (f)
(*d*) Grasses	*Cenchrus catharticus* (c)
	Eragrostis cynosuroides (c)
	Panicum antidotale (f)

3. MOUNTAIN TOPOGRAPHY

(*a*) Trees	*Euphorbia nerifolia* (c)
	Grewia populifolia (f)
	Commiphora mukul (f)
	Acacia senegal (f)
	Lepidagathis trinervis (f)
	Anogeissus pendula (frequent in rocky formations)
(*b*) Grasses	*Aristida hirtigluma*
	Elionurus royleanus
	Pappophorum elegans

c = common. f = frequent. o = occasional.

Silviculture of the species and afforestation—The silviculture of most of the species mentioned in the list as also that of exotic desert species has yet to be studied in detail in that tract and a Research station has just been started at Jodhpur for the purpose. Where sand is fairly fixed, one would naturally think of *Prosopis spicigera*, as it is the most common species in such tracts, but there may be considerable difficulties in raising the species. It is

believed to concentrate more on developing its root system in the initial stages rather than of the shoot portion. All this has to be studied carefully before launching on large scale afforestation measures.

One of the recommendations of the *ad hoc* committee is the creation of a five-mile wide forest belt to withstand the onslaught of blown sands from West and South-West. It is probably not the intention straight away to start afforestation in this area. It will first be duly constituted into a reserved forest. The development of natural vegetation which is expected to spring up in the locality as a result of exclusion of grazing and browsing by camels, sheep, goats and cattle, following reservation, will be watched and artificial regeneration measures will presumably be undertaken later to supplement natural re-vegetation wherever necessary. In this connection a popular misconception has to be corrected. There is an impression that the afforested areas will all be watered till the plants establish themselves. This is not so. The plants will depend for their establishment only on the rains which fall in the tract and there will be no irrigation.

Chemical analysis of the Rajasthan desert soils --In the course of our tour of the Rajasthan desert area representative samples of soils were collected from Jodhpur South-Westwards to the sea coast and also from Jaipur. A few soil profiles were also studied ; and samples of soils taken from different depths have been analysed. On account of the limited time at our disposal it was not possible to cover the whole desert area in a systematic manner or to collect a larger number of samples. The salt contents of the samples have been assessed with a view to determining their possible toxicity to plant growth and to find out the extent of formation of sodium clay in the soil, as the latter influences in some measure the retentivity of moisture in the soil. The following table gives the analyses of some of the representative soil and sand samples.

Results of chemical analyses—The results of the chemical analyses of these desert soils have brought to light very many interesting points and these are discussed below.

Salt content of the desert soils—The salt content of the desert soils (aeolian origin), particularly of the alkali chlorides (the percentage of which is in the third place of decimal) is not so high as to be toxic to plants (*vide* item Nos. 16-27). Therefore, there is no question of removal of salinity of the soil before afforestation.

Further the variation in the total salt content between the different soil samples, except those which were actually collected from areas inundated by the salt waters of Luni river, is not significant. This militates against the theory held by some workers that the salt is borne by wind from the Arabian Sea. It this theory were correct, one could expect the total salt content of the top-soils to increase as one proceeds towards the sea.

Formation of sodium clay and moisture retentivity in the desert soils—The presence of small amounts of sodium salts, particularly the carbonates, induces the formation of sodium clay in the desert sands. This slows down the rate of percolation of rain-water through the sand, with the result that moisture is present in the root region of the plants for a longer time. Thus the presence of small amounts of sodium salts in the desert sands, where the annual rainfall is sometimes as low as 4 to 5 inches, is very helpful to the plants.

Floods in Rajasthan desert areas In Rajasthan sandy desert areas even small falls of rains are reported to cause floods. The reason is not far to seek. Floods are caused when the rate of precipitation is greater than the rate of its percolation into the soil. This "rainfall excess" must flow on the surface and may cause floods. As already mentioned, in the Rajasthan desert soils, the presence of certain salts leads to the formation of sodium clay which retards the rate of percolation of rain-water into the soil. Consequently there will be considerable "rainfall excess" or "run off" and floods are caused.

Serial No.	Soil and Sand	Salt content: Chlorides %	Salt content: Carbonates %	Salt content: Sulphates %	Salt content: Total %	Nitrates N p.p.m.	pH	Clay %
1	Biaskibaori (Jodhpur) Pit 1, depth 0″–26″	0·0029	0·0053	0·0048	0·0130	0·9	7·2	13·8
2	,, ,, ,, ,, 26″–60″	0·0022	0·0159	0·0039	0·0220	0·2	7·9	15·7
3	,, ,, ,, ,, 60″–72″	0·0022	0·0172	0·0046	0·0240	0·1	8·6	13·1
4	,, ,, Pit 2 ,, 0″–6″ (sand dune)	0·0015	0·0093	0·0062	0·0170	0·9	8·5	6·8
5	,, ,, ,, ,, 6″–24″	0·0015	0·0119	0·0066	0·0200	0·8	8·4	6·6
6	,, ,, ,, ,, 24″–48″	0·0015	0·0106	0·0054	0·0175	0·4	8·4	5·9
7	,, ,, ,, ,, 48″–72″	0·0029	0·0080	0·0026	0·0135	0·9	8·3	6·1
8	Biaskibaori Pit 3 ,, 0″–19″	0·0029	0·0185	0·0036	0·0250	1·8	7·8	15·4
9	,, ,, ,, 19″–36″	0·0044	0·0212	0·0059	0·0315	2·6	8·4	16·9
10	,, ,, ,, 36″–55″	0·0044	0·0212	0·0034	0·0290	0·7	8·5	17·6
11	,, ,, ,, 55″–72″	0·0037	0·0212	0·0011	0·0260	0·3	8·6	18·6
12	Raikabag (immature) Pit 1 ,, 0″–15″	0·0022	0·0159	0·0069	0·0250	7·0	8·4	15·7
13	,, ,, ,, 15″–37″	0·0059	0·0133	0·0023	0·0215	3·3	8·3	16·9
14	,, ,, ,, 37″–65″	0·0022	0·0159	0·0074	0·0255	1·6	8·3	19·0
15	,, ,, ,, 65″–72″	0·0022	0·0172	0·0056	0·0250	1·2	8·7	20·2
16	Jaipur Grass Farm ,, ,, 0″–18″	0·0015	0·0133	0·0039	0·0187	..	8·8	6·5
17	,, ,, ,, ,, 18″–36″	0·0029	0·0133	0·0000	0·0160	..	8·8	7·4
18	,, ,, ,, ,, 36″–65″	0·0029	0·0146	0·0028	0·0203	..	8·8	8·4
19	,, ,, ,, ,, 65″–72″	0·0044	0·0174	0·0042	0·0260	..	8·9	9·1
20	Barmer, surface sand, sand hill No. 1 ..	0·0051	0·0146	0·0083	0·0280	..	9·0	4·9
21	No. 2 ..	0·0051	0·0133	0·0089	0·0273	..	9·2	3·7
22	No. 3 ..	0·0059	0·0146	0·0075	0·0280	..	9·2	3·6
23	Galta (Jaipur) surface sand, sand hill ..	0·0051	0·0119	0·0146	0·0280	..	9·2	3·8
24	Shergarh, surface sand, sand hill No. 1 ..	0·0029	0·0106	0·0015	0·0150	4·8	8·7	2·9
25	,, ,, ,, ,, ,, No. 2 ..	0·0029	0·0093	0·0048	0·0170	3·7	8·4	4·2
26	,, ,, ,, ,, ,, No. 3 ..	0·0029	0·0106	0·0035	0·0170	4·8	8·4	4·0
27	,, ,, ,, ,, ,, No. 4 ..	0·0029	0·0093	0·0068	0·0190	..	8·4	3·7
28	Luni River, surface salt incrustation ..	13·26	0·1150	6·06	19·54	..	9·2	..
29	,, ,, alluvial surface soil from field	0·0556	0·0214	0·0480	0·1250	..	8·4	15·0
30	,, ,, surface sand, sand hill ..	0·0059	0·0106	0·0059	0·0224	..	8·7	6·3
31	Mundar (Sirohi gap) surface sand (non calc.) No. 1 ..	0·0071	0·0106	0·0070	0·0247	..	8·1	6·0
32	,, ,, ,, ,, No. 2 ..	0·0029	0·0035	0·0043	0·0107	..	7·9	5·5
33	Bikaner, Hanumangarh sand	0·0029	0·0132	0·0058	0·0220	2·6	..	4·8
34	Bikaner, Pilibangan, sand	0·0029	0·0132	0·0055	0·0217	1·7	..	3·2
35	Bikaner, Suretgarh, sand	0·0029	0·0132	0·0065	0·0227	4·0	..	3·6
36	Jaisalmer sand No. 1	0·0051	0·0159	0·0040	0·0254	2·9	..	4·4
37	,, ,, No. 2 ..	0·0051	0·0172	0·0051	0·0274	3·8	..	3·6
38	,, ,, No. 3	0·0051	0·0172	0·0047	0·0270	0·8	..	4·2
39	Bhakasar, salty marsh No. 1	13·60	0·0344	1·4856	15·12	..	..	6·7
40	,, ,, ,, No. 2	12·48	0·0344	1·1856	13·70	..	..	8·0
41	,, ,, ,, No. 3	12·48	0·0370	1·3030	13·82	..	..	6·8
42	Bhakasar, six miles, inland sand No. 1 ..	0·0074	0·0185	0·0028	0·0287	1·3	..	2·5
43	,, ,, ,, No. 2 ..	0·0081	0·0172	0·0064	0·0317	1·3	..	3·7
44	,, ,, ,, No. 3 ..	0·0066	0·0159	0·0059	0·0284	2·3	..	..

Alluvial soils of Luni river—The samples of the alluvial soils, subject to inundation by the salt waters of Luni river have a much higher salt content than the samples of sands taken from a sand dune in the same area (*vide* items 29–30 in table given above). This shows that the sands of the sand dunes of the locality are of aeolian origin and their content of salt will be seen to be of the same order of magnitude as that of the aeolian sands given in item Nos. 16–27 and 34–39. As these alluvial soils contain a fair amount of clay as well as alkali salts, considerable sodium clay formation is likely to take place. As a result the soil pores are clogged and the soil becomes impervious. Thus even with a mild shower the run off might be large and large areas in the flat lower reaches become water-logged and become one sheet of water which remains for a long time. This phenomenon is seen in the lower reaches of Luni river.

Nitrates in the Rajasthan desert soils—The chemical analyses of these desert sands also revealed the presence of a fair amount of nitrates varying from 1 to 7 parts per million. These are not of biological origin, but form part of the total salt contents. Some of the fresh aeolian sands contain a higher percentage of nitrates than the stabilized sands. This is under further investigation. This probably accounts for the Rajasthan desert area putting on a green mantle with just a mild shower, and for the high fertility of the soil.

Percolation experiments with the desert soil—Some experiments were conducted to study the effect exchangeable sodium and calcium ions on the percolation of water through soil and sand. The table given below shows the time taken for percolation by distilled water through 2·3″ layers of local loam and a desert sand, resting on filter paper.

Treatment	Percolation time		
	Loamy soil with 13·8% clay	Desert sand (Barmer) with 3·7% clay	
	hours	min.	sec.
Control	7	12	55
Ca-treated	5½	8	37
Na-treated	17	12	52

From the above it is clear that treatment of soils with calcium forms the crumb structure which increases the rate of percolation. while those treated with sodium lose their structure and sodium clay is formed. This clogs the pores of the soil and decreases the rate of percolation. Increase in clay content decreases the rate of percolation several-fold. But the most interesting result observed is that even after a further salt treatment the rate of percolation of the desert sand did not decrease. This just shows that the natural salts present in the desert sands have already exercised their maximum influence in this respect.

Inferences from the chemical analyses of the Rajasthan Desert soils—These chemical analyses show that the Rajasthan Desert soils do not contain salts in quantities toxic to plant growth and that they are present in that desirable moderation to impart a certain amount of impermeability to the soil to keep the rain or other water in the region of the plant roots for a longer time. They indicate that the soils are moderately rich in nitrates which are

readily available to the plants. The percolation experiments conducted with a typical sample of desert soil suggest how floods are caused in the Rajasthan sandy deserts even with small rainfalls and how the large flat expanses of land near the mouth of Luni river remain inundated for long periods even after the rains.

This is only a preliminary report and after the work on the desert soils is completed, a fuller report will be published. All the chemical analyses and the experiments were conducted by Dr. R. S. Gupta, the Soil Chemist, Forest Research Institute.

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REGENERATION OF THE *BONSUM-AMARI* FORESTS OF ASSAM*

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1. This paper is a contribution to the study of the problem of the regeneration of Tropical Evergreen Forests of India, being a note on the progress made in this particular type of evergreen forests.

2. *Distribution*—The *Bonsum* (*Phœbe goalparensis*, Hutch.) – *Amari* (*Amoora wallichii*, King.) forests of Assam occur in certain well-defined zones in Assam : the main zone consists of two separated patches on the north bank of the Brahmaputra in the District of Darrang and Eastern Goalpara while a second zone is the alluvial flats and foot-hills between the Mikir and Naga Hills in the Districts of Nowgong and Sibsagar. *Bonsum* and *Amari* trees also occur sporadically on the out-laying spurs of the Khasi Hills in the Khasi-Jaintia Hills District and also on the foot-hills of the outer Himalayan Ranges in North Kamrup District adjacent to Bhutan. This notes deals primarily with the forests in the Darrang District.

3. *Climate of the Forests* – (*a*) *Temperature*—No data as regards temperature variations or ranges inside the forests themselves are available but from records of stations maintained in areas close to the forests it is seen that the temperature ranges from 52·4°F. in January to 78·3 in August. The ranges and variations are probably somewhat lower in the forests themselves.

(*b*) *Rainfall*—Here again there are no records as regards the incidence in the forests themselves but the records maintained in tea-gardens, etc., in the neighbourhood show the average annual incidence as in the neighbourhood of 250 cms. or approximately 100 inches.

It is probably correct that in the forests themselves the incidence will be considerably greater. There are no months in which there is no rainfall, the months from November to March registering less than 5 inches and with an average of over 20 inches in each of the other months.

(*c*) *Humidity*—There are no figures for the forest areas themselves but neighbouring stations record monthly percentage of humidity between 80 and 91·1.

4. *Ecological Status*—Describing the vegetation of what may be considered the type area for the purpose of this paper, viz., the *Bonsum-Amari* forests of the Darrang District, Bor (1) recognizes these forests of the sub-mountane areas of the Himalayan Range as a climax formation and labelled it the *Laurus-Melia* hylium. He further describes the forests as follows :—"High evergreen forests with an admixture of deciduous species, where the rainfall is 200–300 cms. The underwood and shrubby undergrowth are all evergreen. A tall impenetrable forest with cane-brakes, patches of bamboo and a profuse growth of climbers. Many of the dominants have plank-buttresses". Bor, further states that he had decided to call the formation the *Laurus-hylium* because the bulk of the dominants can be relegated to one or other of the two families *Lauraceae* and *Meliaceæ*.

5. *Structure and Floristics*—The forests are many-layered. There is an emergent layer of species, mainly of the softwood type, deciduous by nature and dependent on wind as regards seed-dispersal. The principal species of this very open emergent layer are *Tetrameles*

* This paper originally presented at the Eighth Silvicultural Conference 1951.

nudiflora, *Ailanthus grandis*, *Bombax malabaricum*, *Alstonia scholaris*, *Stereospermum chelenoides*, *Chikrassia tabularis* and locally *Altingia excelsa*. This layer is generally over 40 meters (132 feet) in height. Immediately below the emergent layer is what may be called the dominant layer of trees which is almost exclusively evergreen in nature. The canopy here is fairly complete. Of the *Lauraceæ* the following are the principal species, viz., *Phœbe goalparensis*, *P. attenuata*, *P. haineseana*, *Beilschmiedia roxburghiana*, *B. brandisi*, *Cinnamomum cecicodaphne*, *Alseodaphne keenani*, etc. Of the *Meliaceæ* the following are the principal species, viz., *Amoora wallichii*, *Dysoxylum binecteriferum*, *D. hamiltonii*, *Cedrela toona* and *Chikrassia tabularis*. Other species in the dominant layers are *Talauma phellocarpa*, *Canarium bengalense*, *C. resiniferum*, *Duabanga sonneratioides*, *Adina griffithii*, *Artocarpus chaplasha*, *Sapium baccatum* and *Morus lævigata*. The density of the middle canopy varies but in general it is fairly dense except in Panchnoi Block of the Darrang forests. The principal species in the lower storey are *Talauma hodgsonii*, *Echinocarpus assamicus*, *Dillenia indica*, *Castanopsis*, spp., *Cratæva religiosa*, *Laportea pterigostygma*, *Premna bengalensis*, *Gynocardia odorata*, *Actinodaphne obovata*, *Gryptocarya*, spp., *Polyalthia jenkinsii*, *Pterospermum acerifolium*, *P. lanceæfolium*, *Vatica lanceæfolia*, *Meliosma simplicifolia*, *Garcinia*, spp., *Polyalthia jenkinsii*, etc. The herbaceous and shrubby layer consists of *Clerodendron hastatum*, *C. squamatum*, *Dracæna ensifolia*, *Coffea bengalensis*, *Elatostema platyphyllum*, *Phlogacanthus anviflorus*, *Gnetum gnemon*, etc., in the fairly well-drained areas. In the poorly drained areas there are colonies of canes, *Calamus erectus*, *C. flagellum*, *C. floribundus* and also of *Pinanga gracilis*.

Climbers abound—Apart from the climbing species of *Calamus* the principal climbers are *Buettneria aspera*, *Entada scandens*, *Spatholobus roxburghii*, *Acacia pennata* and *Tinospora cordifolia*.

Among epiphytes the commonest are various kinds of *ficus*, many of the giant *Ficus bengalensis* and *Ficus religiosa* trees now found engulfing dominant layer trees having perhaps started originally as epiphytes. Orchids of the following species are common, viz., *Cymbidium aloifolium*, *Aerides multiflorum*, *Vanda teres*, *Dendrobium formosum*, *D. moschatum* and *D. densiflorum*.

6. *Quantitative data in respect of occurrence of trees of present commercial value*—In the course of preparation of the Working Plan in 1939–40, total enumeration of the important species of present use was effected over about 13,000 acres of the Darrang Forests and it was found that about 6,000 acres had a stocking of 5 trees or more per acre, about 4,500 acres had between 2 to 5 trees, and about 2,000 acres of poorer stocking. In the best first class areas there was a stocking as high as 30 to 40 useful trees per acre. In general it was found that 80% of the total growing stock of useful species was comprised of *Bonsum* and *Amari*, the proportion of *Bonsum* to *Amari* varying from 1 : 5 to 1 : 20 with an average of 1 : 6 or so. As regards the proportions between size - classes of *Bonsum* it was found that about 60% of the total growing stock of *Bonsum* was over 7 feet girth with the balance 40% fairly equally represented in each girth-class below. The forests in general are over-aged and the present 7 feet and over girth trees have to be made to last over a considerable period of years for the sake of maintaining fairly sustained yield. It will be seen from the foregoing that with a full dominant canopy in general, the basal area of present valueless species would be considerable. Considering that if the average girth of the dominant trees is 9 feet and the number of trees in a full canopied forest being about 30 trees per acre of which only 6 or 7 per acre are useful trees, it will be found that about 170 sq. ft. of basal area of timber in the top canopy itself will have to be girdled to permit of the reproduction growing up. Considering also that there would be about another 60 trees of averge girth 4 feet and about 120 trees per acre between 2 feet and 4 feet girth in the middle storey, which would also be of species which have no present value, the required removal per acre of basal area will be in all about 350 sq. ft. per

acre. Thus for every acre of regeneration to be achieved, girdling or otherwise removal of 350 sq. ft. basal area of valueless trees will have to be effected.

7. *Phenological data in respect of important species—Bonsum* (*Phœbe goalparensis*) is a species which seeds profusely every third year, and seeds moderately every second year. The fruit is a fleshy drupe, which is avidly eaten by the horn-bills common in these forests, as well as by pigeons and other frugivorous birds. Whenever dispersal of seed takes place other than to areas underneath the crowns it is by means of the fortuitous agency of these birds. It is very commonly noticed that *Ficus bengalensis* trees have beneath them a fair amount of reproduction of *Bonsum*, this species of tree being the usual abode of horn-bills, as noted by Salim Ali (2) the fruit are ripe in October–November and it would appear that there is a resting period of about two months. Germination commences in January and is completed by the middle of February. Under nursery conditions the percentage of germination is very high. In a good seed-year, an average good tree can produce up to about one maund of fruits.

Amari (*Amoora wallichii*) is a species which fruits almost every year, the fruits having a fleshy fibrous covering. Apart from seed which falls through dehiscence, below the crowns of trees, it would appear that fruit dispersal takes place fortuitously through the agency of bats and pigs.

Gonseroi (*Cinnamomum cecicodaphne*) fruits ripen in August–September and the fruit is very much like that of *Bonsum* except that the pulp is even sweeter and more avidly eaten by horn-bills and other frugivorous birds. Fruiting is heavy every third year and fair almost every year.

Talauma phellocarpa is another fleshy seeded fruit, the seeds ripening from August to September. Probably good seeding occurs in alternate years and fairly large quantities say 10 to 15 seers of fruit are produced per fair-sized tree.

It will be observed from the foregoing that if fully stocked areas of reproduction are wanted the seeds from the bases of the trees occurring with a stocking of about 6–7 trees per acre will have to be transported by human agency and sown in areas between the crowns of useful trees, or transplanting of nursery stock or other artificial means will have to be adopted.

8 *History of regeneration techniques* – (*a*) *Artificial regeneration prior to the introduction of the writer's plan*—The initial attempts in 1929 at regeneration in respect of the principal species, *Bonsum*, were confined to the sowing of seeds at stake, 20 feet between the lines and 6 feet apart in the lines themselves, apparently after clear-felling the trees of the plantation area. This technique appears to have been continued till 1938 when line sowing under shade of *Tephrosia candida* was adopted, the inter-strip kept unplanted being 6 feet wide. Two or three plantations raised under this technique appear to have survived, but in general the technique had the serious defect that the *Tephrosia candida* usually dies in the third year or so and then the inter-linear jungle grew up enormously mainly in the form of *Eupatorium* or rank grasses tending to choke the plant lines, though they may have reached a height of about 3 to 4 feet. To remedy this defect, in 1940 a small area was taken up for transplanting with 2-year old plants, between *Tephrosia candida* lines in the rains. This technique yielded satisfactory results although the weeding costs continued to be heavy and eventually proved to be the basis of future work.

(*b*) *Plantations after the inception of the author's plan*—Here the plantations were created after establishing good lines of *Tephrosia candida* by direct sowing between the cover-crop lines in the middle of March, and filling vacancies by transplanting in the cold weather months of September to November. The technique was to use transplants not less than 4 feet in height and also to prune off all side-branches and leaves before transplanting with

balls of earth. Two advantages were expected, viz. (1) that the plants would be above serious weed competition commencing as they did with an initial height of 4 feet at least and receiving three full seasons of protection and shade from the *Tephrosia* (2) that the irksome rains transplanting with the danger of breaking up of the balls of earth, in a season of maximum difficulty for getting labour were avoided. In 1948, the author found certain areas which had been sown with *Ajhar* (*Lagerstrœmia flos-reginæ*) and it was decided to utilize this plantation for *Bonsum* transplanting. After fairly drastically thinning out the *Ajhar, Bonsum* transplants of minimum 4 feet height were transplanted in the inter-linear space. Here the advantage sought was to get permanent shade, the *Ajhar* taking the place of the *Tephrosia candida* which has an average life of 3 years only. Excellent results have been obtained.

The question of costs in respect of plantations raised on the basis of transplanting was an important one, in view of the casualties and the care necessary with balls of earth each transplant costing about 3 annas. In 1949 certain experiments were initiated in respect of what is locally called 'hospitalizations'. Here the nursery-stock after pruning of all side-branches and leaves, are dug up and bundled together and planted in loose sand in a pit kept permanently moist under shade for periods varying from a fortnight to a month, so that they could recover from the shock and grow new root-hairs. The plant bundles are then removed from the sand-pit and each plant planted out as in the case of plants with balls of earth. The initial experiment with a few plants did not succeed owing to the fact that the subordinate entrusted with the work did not prune off the leaves properly and planted the stock out in areas with insufficient *Tephrosia* shade. This matter will be dealt with later on in this paper.

(c) *Assisted natural regeneration prior to the commencement of author's plan*—Meanwhile from about 1938 certain experiments in respect of assisted natural regeneration had been initiated in two ways as follows :—

(1) Certain mother trees were chosen situated in C. Class areas (poorly stocked areas) and all undergrowth and middle and low canopy trees cut out for a radius of about 20 to 30 feet round the trees. After seed-fall a fair amount of recruitment was obtained. The plants, under the mother trees situated far apart – sometimes a quarter of a mile from one another were, however, difficult to tend in the rains ; it was also found that the small clearings and the light grass and other vegetation that sprang up therein attracted wild elephants and bison which caused considerable damage. A certain amount of damage was also caused by drip from the mother trees.

(2) Certain areas, where, owing to fortuitous circumstances such as occurrence of *Ficus* trees and optimum conditions for growth such as loose earth of saw-pits, cart-tracks, etc., advance reproduction from the recruitment stage and upwards up to 3 feet height was found, were taken up for weeding after removing practically all the low and middle canopy.

9. *The technique of regeneration prescribed under the author's plan*—In choosing the Selection-cum-Improvement system with assisted natural regeneration as the technique to be adopted for the management including regeneration of these forests the author (3) wrote as follows in 1940 :—

"The principal species, whose management is the objective, are shade bearers and some even shade-demanders, at least in the earlier stages of their development. Therefore drastic canopy openings are impracticable, at least initially. The present knowledge about these species is that in the earlier stages they require shade. It has not definitely been established that in their initial stages the shade of the mother

trees properly spaced in the topmost canopy will be sufficient. The present technique which has given satisfactory results over limited areas, where only regeneration has been attempted up-to-date, indicates that there should be a gradual raising of the height of the shade-giving canopy for the progress of the seedlings. This precludes, in the present state of our knowledge, the production of an even-aged forest by a removal of all middle canopy and low canopy trees, among which are a considerable number of saplings poles and middle-aged trees of the species whose regeneration is attempted. Considering that the seed of none of the major species is light and thus capable of being carried long distances by wind or rain, the effective range of seed-dispersal is not probably more than $1\frac{1}{2}$ times the crown diameter, i.e., about 60 feet. It is apparent that if sole dependence is placed on natural seed-fall then new regeneration can only be created in the very areas where the existing mother trees stand with only slight increase in the eventual stocking of the forests, and that if a fairly full stocking of the forests with valuable trees is to be effected then seeds will have to be sown or transplanting done in the areas not covered by the crowns of useful species".

Therefore the plan chose for intensive regeneration areas in the Sopai Block where exploitable trees had been heavily removed under the previous working scheme, as well as similar other areas of the working circle, and detailed that a general shrub-cutting should be done prior to the rains when labour is available in plenty, and that towards the close of the rains in September, lines 4 feet wide should be cut straight through the area and good quantities of seeds from areas not yet taken up for regeneration should be collected, pre-treated, and sown in the lines.

The idea behind the shrub-cutting before the rains was to take advantage of natural seed-fall of *Amari*, *Gonseroi* and *Sopas*, etc. and the opening of lines in September is to permit of *Bonsum* seed-fall on the cleared ground. There was also the consideration of labour difficulties in the monsoon period itself. Germination of *Bonsum* was expected to go on till the end of February and thereafter the prescription was to carry on with a pre-monsoon and post-monsoon weeding.

Where work on the above lines was not contemplated to be done in other worked over areas, it was prescribed that mother trees down to 4 feet girth should be spaced 120–150 feet apart, removing the additional trees as per yield prescription. The whole operation was to be done carefully so as to create no dominant canopy gaps greater than 40 feet in diameter. Dense low canopy was prescribed to be thinned out, but the middle canopy was prescribed to be left untouched pending the formation of reproduction in the lines. When sufficient numbers of lines of adequate reproduction about 3 feet in height had been obtained the middle canopy was prescribed to be gradually thinned out by removal of successively larger sizes, heavy-shading trees such as *Dillenia indica*, *Pterospermum acerifolium*, *Sterculia villosa*, etc., being the first to be removed. It was further prescribed that when the plants in the lines were 6 feet high, the over-girth mother trees should be removed. As regards ensuring regeneration of other useful species, apart from recruitment expected from natural seed-fall after the pre-monsoon shrub-cutting, cold weather transplanting with balls of earth was prescribed. As regards removal of trees of the dominant canopy of unutilizable species when the reproduction had become 6 feet high, it was prescribed that this should be effected by girdling, or poisoning with sodium arsenite, the advantages of this method being considered to be considerable lessening of the damage to the plants, reduction of costs and gradual introduction of light.

10. *Actual technique adopted in attainment of regeneration and improvement in technique visualized*—It was found that the cutting of the undergrowth and clearance of lines in themselves involved considerable loosening of the soil. In addition the Naga labour employed their 'daos' to make small notches and to dibble in the seed as they would their own paddy,

Excellent lines of reproduction were obtained, and in the second and third years the surplus plants were used for transplanting with balls of earth in the new areas to be opened up. This method obviated dependence on an uncertain seed year.

It was later decided to give up the line-sowing technique and adopt cold weather transplanting at a spacing of 6 × 6 feet after removal of some portion of the low and middle layers. A decision was also then taken to increase the transplanting spacing to 9 × 9 feet. Actually it was found that only one weeding in the rains was necessary with a climber-cutting towards the end of the monsoon period. To cheapen cost in transplanting it was decided to have nurseries in the form of lines prepared in advance under canopy near the future planting site.

Pre-occupation with World War II timber-supply work reduced the tempo of silvicultural work soon after the inception of the plan, though some areas were tackled up in 1944–45 in the Rowta, Panchnoi and Sopai Blocks in worked out coupes. Thereafter no attempts were made to continue the work until 1948, but the failure to keep up nurseries hampered a re-commencement of intensive work on a large scale. Meanwhile the heavy fire-wood demand of the War period also had disappeared so that there was no scope for the removal of lowermost canopy trees and transplanting in 1949 and 1950 came to be done in very closed canopy conditions. Very large transplants up to 12 feet in height were used the planting spacing being increased to 12 feet. This in turn compelled the removal of some of the lowermost heavy shade and this was done by girdling and poisoning with Sodium arsenite.

It was soon found (as already forecast by the author initially but in respect of which he had been over-ruled for the sake of being cautious) that the removal of large and saleable trees from above established reproduction posed a problem, as their felling and utilization resulted in considerable damage to the plant lines, a fact which was the more serious as none of the species *Bonsum*, *Amari*, *Gonseroi* or Sopa were good coppicers. It has, therefore, been decided that in future all over-girth exploitable trees should be removed initially before the area is taken up for regeneration without, however, creating large blanks in the dominant canopy. To reduce the cost of transplanting, apart from the adoption of even wider spacing which is possible because of the non-branching nature of all the species, it was decided to experiment with 'hospitalized' nursery stock. In 1950 initial experiments in this regard were made, the transplanting after hospitalization being effected in the rains. The results have been eminently satisfactory. In 1951, the 'hospitalized' transplanting technique is being tried even in the cold weather period, accurate data as regards dates of transplanting and survival percentage being kept. So far the mortality has not exceeded about 5%.

The optimum amount of shade to be retained in terms of the basal area per acre of trees of different layers, and the rate of removal in successive stages, are under investigation by the Silviculturist. Considering that the rate of diameter growth of *Bonsum* varies between that of 1st and 2nd quality Sal from about 4 feet girth onwards till nearly 7 feet girth is reached, and considering that *Bonsum* trees less than 4 feet girth have no market value and that the species is not one that branches unduly even grown rather wide apart, it has now been decided to have an initial planting spacement of 24 feet, the same as for Sal of that crop diameter, thus achieving a considerable reduction in the cost of planting.

In respect of nursery practice it has been found that nurseries raised under forest canopy have got the following defects, viz. (1) the danger of the sown seeds being removed by birds (the danger of drip from the dominant canopy), squirrels, pigs, etc., and of being trampled down by elephants (2) if, to get maximum growth, all canopies except the dominant are removed and heavy weeding done (3) watering of species to hasten germination in the case of species like Sopa is not easily possible. To overcome this it has been decided to have

the nurseries initially near the Beat headquarters under artificial thatch shade and when the plants have reached the 3-leaved (or more) pricking-out stage, to put them out in the forest nurseries until they reach 4–5 feet height when they are dug up and 'hospitalized' near the Beat headquarters, before finally being transported for planting out in the forests.

The use of Sodium arsenite has been found somewhat troublesome because of its poisonous nature and recently attempts have been made to kill trees by use of '*hing*' (*Asafœtida*). The first trees so attempted to be killed were the enormous *Ficus bengalensis* trees which are common in the forests and occupy large areas of dominant canopy space, and underneath which reproduction springs up but is suppressed. About a dozen holes were drilled in each of these trees and about 1–2 ounces of '*hing*' (*Asafœtida*) introduced and the holes plugged. This did not kill the trees, though they showed the effects by leaf-wilting. It is now proposed to try repeated application of '*hing*' (*Asafœtida*) and also to apply this method to other less resistant useless trees, as once used '*hing*' (*Asafœtida*) can be used over and over again for killing more trees.

11. *Acreage of regeneration achieved so far*—By the adoption of the techniques detailed above about $1\frac{1}{2}$ square miles of forests have been so far regenerated since 1948, the oldest areas being now in need of thinning. The progress made is not inconsiderable considering the fact that about 3 years were lost. When the results of research into the 'hospitalization' process, the optimum periods of plantings, optimum degrees and spacing of canopy removal, and the use of a suitable chemical for girdling useless trees are known, it is hoped that a technique will be evolved which can attain cheap, rapid, and full regeneration of large areas of this type of evergreen forests.

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THE UTILIZATION OF INFERIOR TREE SPECIES AND LOGGING WASTES IN THE MOIST SUB-TROPICAL FORESTS OF EASTERN INDIA

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SUMMARY

The efficient utilization of the moist sub-tropical forests of Eastern India has so far been one of the most baffling problems in our forestry practice, due to the preponderance of numerous hardwood species that have either no value as timber at all, or are so low grade that their extraction usually does not pay. The few useful species that occur are again so scattered in distribution that their extraction is likewise very often uneconomic. The enormous wood waste, which is estimated to be about 10,000 tons (50 c. ft. each) annually in North Bengal with only about two-thirds of the prescribed clear-felling done at present, and obviously several times as much in Assam, is to-day regularly burnt in the clear-felling areas, or left in the forest to rot elsewhere.

The best way to utilize these inferior species, and logging wastes including thinnings in many cases would appear to be some form of chemical conversion whereby the value of the wood substance is so appreciably increased as not only to cover the costs of extraction, processing and subsequent transport to the markets, but also to give an end product which has a steady or rising demand in the country. Various methods of chemical utilization of wood waste, including carbonization and destructive distillation, other forms of wood distillation, pulping for paper, manufacture of fibreboards, hydrolysis to produce sugar and ethyl alcohol and the use of wood waste in the plastics industry, etc., are considered and their applicability in this region is discussed both from technical as well as from economic points of view. It is concluded that the manufacture of various kinds of *hard* fibreboards in decentralized plants such as are now in operation in many of the Central European countries and in the U.S.A., is likely to be one of immediate and wide applicability in this area. There is no scope of destructive distillation on a conventional scale as a profitable undertaking, due to the very generally doubtful economic prospects of byproduct recovery and to the rather limited local demand of charcoal which is the main end product in this method of utilization. To meet the existing regional demand of charcoal for domestic use by the few hill towns, carbonization in native kilns should be continued with partial recovery of byproducts with inexpensive equipments that have recently been evolved in China, if the latter proves profitable. A new demand for charcoal high in carbon content and free from tar, such as can only be produced in retorts under controlled conditions, for use in specialized chemical industries like case-hardening, activated carbon and production of carbon bisulphide is slowly developing ; this may eventually permit or necessitate the operation of smaller distillation units in certain localities, usually without recovery of byproducts, as have recently been evolved in Switzerland and U.S.A.

The potentialities of several other methods, viz., special forms of hardwood distillation for the manufacture of nitrogenous fertilizers (through the synthesis of Ammonia) and methanol, the manufacture of paper pulp, acid hydrolysis and the use of wood waste for plastics industry are indicated, although they are not considered immediately or widely applicable in this region. It is also pointed out that the economics of any undertaking on chemical wood utilization can be best ensured if such is integrated with one or other of the major wood using industries like saw-milling, plywood manufacture, etc. Also it seems that except for the very specialized chemical industries, the pioneer undertakings in the methods of chemical utilization of wood waste suggested here would have to be initiated as State enterprise, in order to demonstrate their economic prospects to the rather conservative industrialists of the country.

INTRODUCTION

The moist sub-tropical forests of Eastern India are characterized by a preponderance of numerous low grade hardwood species whose utilization has so far been a very baffling problem in our forestry practice. While there are still some fine and almost pure patches of *sal* (*Shorea robusta*) here and there, with continued fire protection during the last several decades, large tracts of what was once largely pure *sal* forest in North Bengal and Assam are now almost completely covered with a luxurious growth of a very large number of evergreen hardwood species (locally termed 'kukat', meaning useless wood) of which only a very few can be classed among commercial timbers. And again, the very scattered occurrence of what are reckoned as useful species, e.g., *Michelia champaca*, *Artocarpus chaplasha*, *Phœbe hainesiana*, *Terminalia crenulata*, and *myriocarpa*, *Schima wallichii*, etc., and in addition *Dipterocarpus* spp. and *Mesua ferrea* in Assam, render their extraction very often uneconomic (29). The future management of these forests, however, is aimed at producing purer and concentrated crops of commercially valuable species, mostly by artificial regeneration. But it would be a long time before we can expect to get to the stage when it would be possible to extract any one species profitably for timber. And even when we have been able to handle more or less pure crops of commercially valuable species, the efficient utilization of thinnings, tops and branchwoods would not perhaps be too simple, as these forests are, except for certain blocks with Tea Estates in the neighbourhood, situated far away from the larger settlements of the population of the country so that the very long lead to the markets would doubtless ever prevent their profitable and complete utilization in the usual form of posts or firewood. This has also been the general experience of the foresters of temperate countries, some of whom, e.g., Canada, Sweden, Finland and Russia, are fortunate enough to possess natural forest resources in the form of almost pure stands of commercially valuable species which again are capable of successfully regenerating naturally, while others, e.g., in France, Switzerland, Austria, Germany, etc., as a result of long continued and careful forestry practice, have now been able to handle similar pure stands. It has been estimated that with rare exceptions the timber industry can hardly utilize more that 60% of the solid cubic contents of a tree, with all the modern methods of extraction and conversion (12, 13). The tops and branchwoods are in some areas readily utilizable as fuel or posts, while in others, e.g., large blocks of forests far away from the larger settlements of population, they often present a difficult utilization problem (13, 50). Similar is the case with thinnings, especially the earlier ones, except in particular localities where there is a demand of poles sufficient enough to ensure their complete utilization. Further, when we consider the fact that in these moist sub-tropical regions by the time a pure crop is due for a major felling we have almost invariably to deal with an understorey of evergreen, mostly unwanted, hardwood species that come in naturally, despite the various cultural operations designed to minimize their growth it becomes clear that the problem of utilization of wood waste is by no means a temporary phase in our forestry practice.

On a rough estimate, the amount of wood waste comprising entire trees, branchwoods and tops and thinnings is in the neighbourhood of about 10,000 tons (of 50 c. ft. each) solid annually in the North Bengal area only and this is again with roughly 60% of the prescribed clear-felling, and this must be several times as much in the extensive similar forests of Assam. The Forestry Department is occasionally fortunate in being able to dispose of odd bits of this wood waste as fuel in cartloads (the so-called *Dhengras* which is often paid for but not removed by Tea Estates). Normally in the clear-felling coupes they are systematically burnt, while elsewhere in improvement or selection felling areas and in plantations (*thinnings*) they are left as such in the forest to rot.

What constitutes an inferior species is often determined not by its absolute utility and demand for any particular timber industry but by the relation between the cost of extraction,

transport and conversion and the price obtainable for the end product under any particular set of local conditions of labour, transport facilities, distance from rail head and the like. For instance, although species like *Bombax malabaricum, Bischofia javanica, Terminalia belerica, Eugenia* spp., *Tetrameles nudiflora, Anthocephalus indicus,* etc., are somehow marketable in certain localities, e.g., Siliguri and Gauhati, they are reckoned as inferior species in the interior forest divisions for reasons already indicated and as a result entire trees of these species constitute much of the waste. But there are many more which are not utilizable even for the cheapest of packing cases. Examples of species under this category are provided by *Dillenia* spp., *Ficus* spp. various spp. of *Magnoliaceæ, Lauraceæ, Sterculiaceæ, Rubiaceæ, Verbenaceæ, Euphorbiaceæ,* etc., and at present we are not able to conceive them as anything better than firewood, and there again, inferior to the tops and branchwoods of the more valuable heavy hardwoods like *sal, Terminalias, Dalbergia sissoo,* etc. This being the case, their extraction as firewood is generally non-paying, even at nominal or no royalty, except in a few localities with Tea Estates around, where the demand of fuel is sufficiently high to cover the expense involved. It is probable that with the progressive development of various local timber industries and consequent rise in demand of hitherto little used hardwoods, some of these lowgrade species will eventually be profitably utilized by them after seasoning and preservative treatments. But there can be no doubt that there would ever be considerable amounts of wood waste in these forests – for the utilization of which we shall have to find out other means.

Any suggestion towards the solution of the problem would have to be based on the following considerations :—

1. The existing cost of extraction and transport cannot be substantially reduced in the near future, as the extension of mechanized extraction methods and improvement of internal communications require capital investment which the department can hardly be expected to afford for the sake of lowgrade and waste wood only.
2. As most of what constitutes waste cannot now be disposed of even as firewood, the forestry departments would not expect more than a nominal royalty for them at the moment.
3. The method of utilization employed should be such as to cover all the waste wood in mixture both as regards species as well as in dimensions, rather than selected ones in which case sufficient material is not likely to be available within an economic hauling distance.
4. It should be assumed that the end product in any method of conversion or processing employed in this part of India would largely have to be transported by rail over a fairly long distance (300 to 400 miles) for disposal.
5. Any method of utilization envisaged must aim at increasing the value of the wood substance to such an extent as not only to cover the costs of extraction, processing and subsequent transport to markets but also to give an end product which has a steady or rising demand in the country.
6. Lastly, under the present conditions in India, expensive and complicated plants for operating which a high degree of technical skill is required cannot be introduced all at once.

These considerations naturally lead us to think whether it would be possible to subject these wood wastes to some form of chemical or semi-chemical treatment to give an end product that is readily saleable with a reasonable margin of profit. We may, therefore, consider the various methods of chemical wood utilization that have been, and are being evolved to-day in

the industrially more advanced countries, and examine their applicability, immediate and potential, in this part of India.

CARBONIZATION AND DESTRUCTIVE DISTILLATION

In its crudest form carbonization consists in the production of charcoal without recovery of liquid and gaseous products, from billets of varying sizes in the native earthen kilns of which various types are still in existence to-day, particularly in the underdeveloped countries like India. Considering that hardly 40% of the dry weight of the wood substance consitutes charcoal, it would at once appear that such a method of utilization is a wasteful one, in that the gaseous products or "Distillates" are wholly lost. Thus the recovery of the byproducts came more and more into prominence in the Western Countries till by the early part of the present century destructive distillation of hardwoods with recovery of byproducts became a highly specialized industry which in many of the European countries and notably in the United States of America (25, 37) almost completely replaced the primitive charcoal kilns by large central plants with battery of externally heated retorts and with elaborate equipments for condensation and refining of the distillates. The recoverable part of the distillate from hardwoods mainly consists of acetic acid, methanol or wood spirit and wood tar. Prior to World War I the hardwood distillation industry was the sole source of methanol, but later the advent of synthetic processes for the manufacture of this important chemical dealt the industry a blow from which it is hardly likely to make a permanent recovery (11, 20, 21, 26, 46, 50).

It will appear that the distillation of hardwoods involves two distinct operations, viz.—(1) Carbonization of wood and condensation of the distillates and (2) separation and refining of the different constituents of the distillate. Both in European countries and in the U.S.A. the prevailing trend of thought is that the refining of the distillate is now the limiting factor in any project of hardwood distillation and that it is very generally uneconomic (21, 26, 35, 46, 50, 62). The few plants that are still operating in Europe and America owe their existence to "non-competition" and particularly favourable marketing facilities for charcoal produced, rather than to anything else (21). Against this general picture, however, a British plant claims its financial stability to be based on the isolation of organic solvents (methyl acetone, etc.) as a very profitable adjunct (31), and again some in France (47, 52), Austria (7) and Sweden (1) claim that the collection of distillates from portable retorts in the forest followed by refining in a central plant is an economic proposition. And as a matter of fact some wood chemists still believe that the continuing interest in the rare and valuable organic compounds like *guaicol* (35), higher *phenols*, complex organic solvents (31), liquid fuel for internal combustion engines as a byproduct in wood distillation (41) and in the manufacture of "synthetic coal" by controlled carbonization under high pressure (35), etc., may open up new opportunities in the now decadent hardwood distillation industry.

Nevertheless, despite the various claims and beliefs in favour of hardwood distillation in certain quarters there can be no denying the fact that to all intents and purposes it is now a dying industry in the Western countries generally, although the production of charcoal without recovery of byproducts in native or decentralized portable kilns still persists to a varied extent and is frequently resorted to whenever a demand for charcoal arises (20, 26, 35, 46). The position in the U.S.A., which was once the world's largest producer and consumer of hardwood distillation products prior to World War II, is summarized by Panshin and others (50) as follows :—"The prospects of wood distillation are (at any rate in the U.S.A.) *not* considered a profitable way of utilization of wood waste, although an increased demand of charcoal would justify an enterprise ; but generally speaking competitive factors indicate a decline, unless entirely new principles are evolved".

However, early investigations on the destructive distillation of Indian species of tropical and sub-tropical hardwoods (25) revealed that except a very few species like *Caruga pinnata*, *Acacia* spp. (esp. the introduced Australian wattle), cocoanut shells and less favourably bamboos, they are inferior in yield of acetic acid and methanol to the temperate species of European and American hardwoods. This explains why the feasibility of installation of an wood distillation plant in India was considered doubtful even in those days when new plants were frequently being set up in Europe and America during the first quarter of this century. Nevertheless a pioneer attempt was made at Bhadravati in Mysore (19) about a decade back, and another distillation plant has just been installed at Londa, Bombay (5). Of course the main object in both these cases is to utilize the miscellaneous mostly lowgrade hardwoods to produce large quantities of charcoal to be used more or less on the spot for the smelting of iron ores. The operational results of the Bhadravati plant was summarized by its chief chemist in 1946 as follows :—"......Due to cheaper synthetic processes having been evolved for acetic acid, acetone and methanol the wood distillation plant and the chemical (refining) plant are working on a restricted scale, the bulk of the charcoal required for metallurgical purposes being made in the forests in the country kilns and cast iron kilns". It was, however, hoped that although the conventional process of neutralizing the pyroligneous liquor with lime and subsequent remanufacture of acetic acid from the acetate is uneconomic, wood distillation would still be a paying proposition with direct recovery processes for acetic acid such as those evolved by Suida or de Melle (50), as there is a considerable demand for acetic acid in South India and closely situated countries like Ceylon, Java and Malay States which import large quantities of the acid for the rubber industry. But we have not yet got any report from the Bhadravati plant to substantiate those hopes. Therefore, despite the unsaturated market over much of the South-East Asia for both acetic acid and methanol, it would be extremely unwise to go in for any further installation of expensive refining plants for the byproducts of hardwood distillation at this stage in any part of India, particularly in view of the prospects of early development of synthetic processes for the manufacture of these chemicals, which is now almost certainly a matter of a few years.

It may be worth mentioning here that whereas in the industrially advanced countries the collection and refining of the byproducts of wood distillation is regarded as a specialized chemical industry essentially requiring an expensive and complicated series of equipments and carbonization in retorts we have recently had an instance from China (40) where a partial recovery of the distillates has been very profitably made from the native charcoal kilns. A simple and inexpensive condensing equipment, consisting of several bamboo pipes about 12 feet long fitted on to an wooden barrel with an intermediate false bottom, and a few earthern pipes are all that are required to collect much of the acetic acid, with very little operating skill. The distillate so collected is neutralized with lime and dried in iron pans to form "brown acetate of lime". Although this product contains much of the dissolved tar as impurity it is likely to find a ready market in all the south-east Asian countries, and, therefore, considering the very inexpensive equipment required this process is likely to be a very profitable addition to the existing charcoal burning operations, e.g., in the forests of Darjeeling district, to supply the essential domestic requirements of charcoal for the few hill towns.

As the recoverable byproducts consitute hardly about 15% of the dry wood substance it is now evident that charcoal is the *main* product of hardwood distillation and, therefore, the economic success of a distillation project would primarily depend on the prospects of satisfactory marketing of the large quantities of charcoal produced. At present the local demand of charcoal in Eastern India is limited to the domestic needs of the people in the few hill towns, as already indicated. During the last World War a large demand for charcoal for generating producer gas for running lorries and buses (51) developed due to the shortage of petrol, and so did one for "densified charcoal" or charcoal briquettes for running the tea processing plants

as a substitute for coal which was then in short supply due to a partial dislocation of rail transport from the coal mines in Central India. The Forestry Departments in both these provinces could then profitably utilize much of the wood waste through increased production of charcoal in a variety of newly devised kilns. But that demand has now completely faded away with the recent discovery of mineral oils and coal deposits in Assam. Enough petrol is now available for automobiles and other internal combustion engines in the area. And although it is now-a-days technically possible to densify charcoal from any light hardwood and to make there from briquettes closely comparable to coal in calorific value and other desirable properties of industrial fuel (3, 22, 51), it cannot, by any stretch of imagination, be expected to compete in price with coal that is now readily available near at hand from Assam, to cater to the requirements of the tea planters. The only other major industry that can consume large quantities of charcoal is the smelting of iron ores, for which unfortunately there is no plant within a reasonable hauling distance from these forests. It would be too much to expect of the Ironworks of Central India to defray the enormous railway freight for charcoal produced in North Bengal and Assam, when they have more or less on the spot a ready supply of cheap coke, despite the superior reducing properties of wood charcoal on account of freedom from sulphur and phosphorus. It may be recalled here that the distillation plants in Mysore and Bombay have the main purpose of producing charcoal to be used more or less on the spot for smelting iron ores, as in their case the carriage of coke from the coal mines which are all in Central India appears to have proved uneconomic. The combination of a wood distillation plant with an Ironworks has, incidentally, been considered to be a satisfactory form of integrated forestry enterprise in Australia (34) in recent years.

It is thus evident from what has been explained above that there is no immediate scope of increasing charcoal production in this part of India, beyond meeting the domestic requirements of the few hill stations. Although the total requirement of charcoal might at first sight indicate the possibility of a distillation plant, the raw material available for the purpose is too scattered to permit of their economic collection for a central plant. Further the introduction of mechanization for the production of low priced *charcoal for merely domestic use* would throw a large section of the local people (" charcoal burners ") out of employment and, therefore, cannot be justified. A new demand for special quality charcoal with high carbon content and free from wood tar and other organic impurities – such as can only be produced under controlled conditions in retorts, is, however, slowly developing for specialized industries, e.g., case hardening, manufacture of activated carbon and of carbon bisulphide for the growing rayon industry, which undoubtedly can pay a much higher price for charcoal than what is normally obtainable when sold as fuel. This may, therefore, open up an opportunity in future for the profitable utilization of the wood waste by distillation in some localities with better facilities of rail transport of the end product. It has recently been shown in the U.S.A. (62) that due to the exceedingly poor conductivity of wood it must be reduced to an optimum size in order to get uniform quality of charcoal free from tar and other impurities. And again it is now generally accepted (15, 50, 62) that in order to effect an overall economy in power consumption it is very necessary to utilize completely the large amount of heat evolved during the *exothermic reaction stage* (at about 280°C.) of wood carbonization. These considerations have led to the development of portable or semi-portable, continuous, internally heated carbonizing systems, such as are illustrated by the Roth and Strupp kiln (15) of Switzerland and the Mellmann kiln (10) of U.S.A., usually without, and occasionally with partial, recovery of byproducts. These distillation units not only require a *much smaller capital investment* than in the conventional processes of distillation with battery of externally heated retorts, but are also comparatively simple in construction and operational technique, and which are, therefore, most likely to be operable under Indian conditions, when and if the demand for such special charcoal necessiate such an undertaking. Incidentally, the pioneer installation of such a unit must obviously

be integrated with an existing saw-mill, e.g., at Siliguri, as the process involves breaking the wood waste down to an optimum size.

OTHER FORMS OF WOOD DISTILLATION AND THEIR POTENTIALITIES

During the last World War the possibility of developing domestic production of artificial fertilizers based on the fixation of atmospheric Nitrogen and on the use of raw wood as a base for producing Hydrogen, was seriously considered in India, and a pilot plant was proposed to be set up at Alwaye, Travancore, near the port of Cochin (4, 54). Due, however, to the difficulties of shipping essential equipments from abroad, the actual installation had to pend till 1948. This plant is the first of its kind in the world to produce synthetic ammonia using wood and atmospheric air as the basic raw materials. Any species of wood can be used, and it is, therefore, one of the very efficient methods of utilization of wood waste in areas with a preponderance of lowgrade hardwood species such as are found in many of the moist tropical and sub-tropical forests all over the world, and in countries where the need is felt to produce inorganic nitrogenous fertilizers. It is, however, important to note that a very large quantity of wood waste, to the extent of at least 20,000 tons per annum must be made available to such a plant within a reasonable hauling distance ; at Travancore the entire produce of 110 square miles of moist tropical forest with few valuable species, have been exclusively earmarked for supply to the Gas plant at this fertilizer factory (54).

This chemical industry is based mainly on the fact that when wood gas (i.e., producer gas from wood) is passed over red hot Ferric Oxide (Fe_2O_3), it is the Carbon monoxide (CO) that reacts with the Oxide, Hydrogen practically remaining unaffected (54). The process can be roughly divided into four stages, viz., a.) Manufacture of producer gas ($CO + H_2 + N_2$) by distillation of wood with steam, b.) part of the producer gas is directly consumed or burnt to give power for the plant, leaving residual Nitrogen after being passed through lime, c.) the rest of the producer gas is passed *over* red hot Ferric Oxide as a reducing agent and thereafter *through* Soda ash, the resultant gaseous product being a mixture of Hydrogen and Nitrogen and d.) the mixture of Hydrogen and Nitrogen is then led through a synthesising plant to form Ammonia (NH_3).

The technical and economic prospects of the Travancore plant has already inspired the Central Government to set up a much larger plant on more or less similar lines at Sindri, Bihar (2), where in lieu of wood waste lowgrade coke would be used to generate producer gas. In view of the increasing need of nitrogenous fertilizers over much of this vast agricultural country, the possibility for another plant in the forest region of Eastern India, especially in Assam, is worth investigation. The feasibility of an economic unit in this area is further supported by the fact that a large amount of lowgrade coke from the lately discovered coal deposits of Assam and North Bengal (foot-hills of Kalimpong division) would be readily available to supplement the supply of wood waste, if and when required.

Another method of distillation of hardwoods, and perhaps an welcome alternative to the production of fertilizers which is now so well beyond the pioneering stage in India as to soon cover the normal demands of the problem areas, constitutes the synthesis of *methanol* from wood gases, using wood, steam and Oxygen (*from liquefied air*) as the basic raw materials. The process which has recently been developed in France and whose economic and technical possibilities have been successfully demonstrated on a semi-commercial scale (33), is likely to be of considerable interest to countries like India where this chemical, although in great demand, has to be mostly imported at a high price to-day. The present price of commercially pure methanol in Calcutta, for instance, is Rs. 6/8/- or 10 shillings 6 pence per gallon, against about 5 shillings in the United Kingdom.

The chemistry of the process is based on the discovery that when wood is distilled at high temperature in the presence of steam and Oxygen (introduced from time to time in a modified type of producer gas generator) it is completely gasified into a mixture comprising mainly Carbon monoxide, Hydrogen and methane (CH_4), with a certain amount of Nitrogen and traces of Carbon dioxide, and that when this gaseous mixture is subjected to a high pressure (650 kg. per sq. meter) at a temperature of about 425°C. in presence of certain metallic oxides (Zinc Oxide, ZnO, and Chromium Oxide, Cr_2O_3, acting as catalysts) it automatically results in the formation of almost pure (92–97%) *methanol* (CH_3OH). As the composition of the gaseous mixture obtained by this distillation process is independent of the species of wood used, and as the mixture is almost wholly convertible into methanol – unlike the process of Ammonia synthesis where the Carbon content of the original wood substance is either burnt as fuel or is used as Carbon monoxide to reduce the Oxide of Iron and, therefore, does not enter into the end product at all, this is a chemical industry which ensures complete utilization of the wood substance of any species to produce a valuable end product much needed in the country.

The ever-increasing demands of methanol and of its derivative formaldehyde for a variety of growing and pre-existing industries, viz., plastics, rayon, textile, tanning, printing and dyes, etc., for which large quantities of these chemicals are annually imported into India will doubtless lead to various synthetic processes being explored in the country in the near future. Here is a synthetic process which appears to offer a possibility of an efficient utilization of wood waste in a suitable locality in Eastern India. But, whereas the manufacture of fertilizers is directly connected with the most urgent problems of land reclamation and food production and has, therefore, been taken up as a major State enterprise, the manufacture of methanol in India is not likely to be so. There is every reason, however, to expect some of the larger chemical firms to take up this rather ingenious synthetic process if adequate facilities of raw materials are offered to them, and the Forest Departments of this region can perhaps do much to develop this much needed chemical industry by private enterprise, by offering for instance, free of royalty, the required amount of wood waste in a suitable area to an intending firm, during its exploratory operations.

PULPING AND MANUFACTURE OF PAPER

Theoretically any form of wood waste, e.g., logs, branchwood or tops, which can be converted by logging into suitable chips is a potential raw material for pulp and paper manufacture (26). But until comparatively recently only coniferous woods or softwoods, and in the tropics bamboos and woody grasses (23), were considered as the only suitable raw material for pulp and paper, due to their long fibres and, therefore, superior felting properties. But with the progressively threatened short supply of softwoods in the world's larger pulp producing countries like Canada and Sweden, more and more attention has had to be paid to hardwoods, and to-day many of the temperate hardwoods are universally accepted as raw material for a variety of papers (50) including wrapping paper and newsprint (17), and standard pulping techniques for them have been developed both in Europe and in America (17, 18, 30, 32, 50).

In a general way hardwoods are best pulped by milder cooking conditions, whereby the fragmentation of the fibres, which are shorter than those of softwoods, is minimized. Due to the incomplete digestion with chemicals, hardwood pulps retain more of the original components of the wood substance, viz., cellulose, lignin and hemicelluloses, than the standard chemical softwood pulps which constitute almost pure cellulose (17, 30, 32, 50). This accounts for the increased opacity of the hardwood pulps, which is a desirable quality for certain types of paper ; and for the same reason usually a much higher yield of pulp per ton of wood used is obtained from hardwoods than from softwoods (17, 30, 50), a fact worth consideration for

the manufacture of cheaper grades of paper. Further it would appear that the retention of much of the lignin in hardwood pulps partly compensates for their weakness on account of short length of fibres, the *thermoplastic properties of lignocellulose* (60) bringing about a bonding of the fibres against their felting in the case of softwood pulps, during the manufacture of paper.

The earliest suggestion that the tropical and sub-tropical hardwoods might prove to be a potential source of pulping material was put forward in 1940 by Runkel (53) in Germany. Shortly afterwards, Shikata and others (57) in Japan succeeded in pulping some of the medium and lighter hardwoods of the sub-tropical mixed forests of Siam, e.g., *Bombax malabaricum*, *Anthocephalus indicus*, *Grewia* spp., *Hibiscus* spp., *Spondias mangifera*, *Ailanthus* spp., *Milletia* spp., *Ficus* spp., several species of *Sterculiaceæ* and *Moraceæ*, etc., and held that the pulp produced, although of inferior quality, could be used in mixture with softwood pulps to produce several cheaper varieties of paper. Since the termination of the War considerably more attention has been focussed on the pulping techniques for tropical and sub-tropical mixed hardwoods, notably of Belgian Congo (64), French Equatorial Africa (38), Brazil (55) and Argentina (61), and very encouraging reports have since been published. Wilderman (64) in 1946 reported favourably on the prospects of pulping mixed hardwoods of Belgian Congo. Later in 1949 two French workers Le Cacheux and Peteri (38) successfuly pulped mixed lots of hardwood wastes from the French Equatorial Africa, and produced a variety of papers of excellent quality. Almost simultaneously Tortorelli (61) in Argentina and Rys (55) in Brazil both succeeded in pulping mixed lots of mostly lowgrade hardwoods in their respective territories to produce various cheaper grades of paper, including newsprint (55, 61). The present position on the question of tropical and sub-tropical hardwoods as a source of pulp and paper can be summarized as follows, following the conclusions of the fourth meeting of the F.A.O. Sub-committee on wood chemistry held at Brussels, 1949 (8) :—

> "Sub-tropical and tropical mixed hardwood species can be successfully pulped by standard alkaline cooking methods with only minor modifications. When pure stands are not available, cooking conditions can be selected for pulping of mixed species, although in general under these circumstances the optimum yields and properties for each species may not be obtained. It is, however, claimed that in certain cases the cooking of mixtures can even improve the average yield and quality of pulp".

As a result of recent investigations a world shortage of pulp and pulping materials has been confirmed (9). The demand of cheaper grades of paper is fast increasing with the spread of education in the underdeveloped countries like India. There is thus little doubt that mixed hardwoods of the tropical and sub-tropical regions will in no distant future constitute an important raw material for pulp and paper, in addition to bamboos, woody grasses and agricultural waste materials like straw, *bagasse*, etc., that are already being used to a varied extent to make a variety of excellent paper (23), the latter, however, often presenting difficulties in collection from isolated sources because of their bulky nature.

It must, however, be admitted that the paper from tropical mixed hardwoods cannot be expected to compete in quality and strength with those from softwoods, bamboos or grasses. So the economic success of a pulp-paper mill using mixed tropical hardwoods as raw material would primarily depend on the availability of cheap power, in much the same way as a mechanical pulp mill for newsprint. Of no less importance is the cost and availability of chemicals. But as lime, the cheapest possible alkali that can be used, is locally available in abundance, and as the mineral oil deposits of Assam has already commenced producing sulphur on a commercial scale, this item is not likely to be a serious obstacle to the installation of a pulp mill in this part of India. Nevertheless, merely on the question of supply of power, it does not seem possible to go ahead with the installation of a pulp-paper mill immediately in this area. The Government of India have, however, in view, several hydroelectric projects in this region.

notably one on the Tista river. While the installation of a commercial pulp-paper mill will necessarily have to await the completion of such a project, opportunities must be sought meanwhile to set up a pilot plant to investigate into the optimum cooking conditions of the available mixed hardwood wastes, yield and quality of pulp obtainable therefrom and the various economic factors involved. It might as well be possible, as will be indicated presently, to integrate such an investigation with an existing major wood using industry or with other immediately operable methods of chemical utilization of wood waste.

DEFIBRATION AND MANUFACTURE OF FIBREBOARDS

Although the production of pulp for the manufacture of paper is a matter of necessity for the development and perpetuation of our civilized existence, it would appear that the chemical pulping processes are rather wasteful with regard to the utilization of the wood substance. The cell wall substance of wood is composed of three major constituents, viz., cellulose, hemicelluloses and lignin, and in established chemical pulping processes the principal end product is cellulose, so that most or much of the lignin and hemicelluloses, even under the so-called milder cooking conditions, becomes waste products which themselves present exceedingly complicated utilization problems. Despite the wide range of uses, e.g., recovery of alcohol (24, 56), lignin as a soil builder (16), etc., to which the waste liquor of chemical pulping processes are claimed to have been put in different countries, the time is not yet in sight when a profitable outlet will exist for all the lignin (and hemicelluloses) likely to become available from current and prospective processes of chemical pulping of wood or other ligno-cellulosic materials (26). There are, however, other chemical or semi-chemical methods of pulping or *defibration* (as is often the case) of wood chips in which cellulose is not necessarily the end product and which ensures almost complete utilization of the original wood substance. The various processes of manufacture of fibreboards come under this category.

In general, the various processes of manufacture of fibreboards can be broadly divided into two groups, viz. – the *wet processes*, where wood chips are softened with steam or boiling water, with or without the addition of chemicals, followed by the breaking down of the fibres by various mechanical means and the resultant pulp pressed wet without any binder ; and the *dry processes*, where the wood is either chipped and defibrated as in any of the wet processes or is ground or sliced or otherwise mechanically disintegrated into small shavings or particles, and pressed dry with some form of binder of the thermosetting type (12). The well known *Masonite* process of the U.S.A. (39) and the *Asplund defibrating* process of Sweden (43, 44), for instance, are both wet processes. In the former the defibration of the wood chips is effected by a unique explosion process which can be controlled to produce mechnical pulp for some six different types of board. The latter is based on the discovery that wood chips, softened in the presence of moisture at 160 to 180°C. can be ground at these high temperatures to produce a highly defibrated product which gives an overall yield of 92 to 96% of the original dry weight of the wood substance. In both these processes, the pulp obtained is spread into mats of varying thickness, led through a *Fourdrinier paper machine* and pressed wet at high temperature and pressure to form boards of varying densities, strength and other properties. It has now been adequately shown that the fibre length of the wood used is practically immaterial in the manufacture of fibreboards (8, 12), and, therefore, these processes are equally applicable to the tropical and sub-tropical mixed hardwoods. But unfortunately the Masonite and Asplund processes are only operable on a large scale, and require complicated series of equipments and a high degree of technical skill, apart from a large capital investment. Although the demand and popularity of fibreboards, particularly of the *hardboards* is steadily increasing to-day all over India due to an overall shortage of timber, the time is not yet ripe in India for the operation of these processes requiring a high degree of technical skill and experience. There are, however, various other processes that have recently been developed for the manufacture of

fibreboards, which are operable on a comparatively smaller scale, requiring much less technical skill, in decentralized plants with fairly simple set of equipments – and some of which are, therefore, most likely to be immediately applicable under the present conditions in India, as pioneer undertakings.

According to a wet process recently developed in Italy (45), known as the *Xilon* process, chips from any species of lowgrade hardwood can be easily defibrated at ordinary temperature and pressure by attrition after a preliminary digestion with a small quantity of reasonably cheap chemicals (viz., 15–20 Kg. of *soda ash* or its equivalent in *lime* and 30 Kg. of *sulphur* per dry ton of wood chips). The pulp so obtained is formed into a thick mat and pressed wet under a hydraulic press at a high temperature without any binder, to form hardboards closely comparable to, or even better than, the Masonite or Asplund type of boards. Although any mixed lot of lowgrade hardwoods can be used, those richer in lignin have been found to produce stronger boards. In another process developed recently at the U.S. Forest Products Laboratory (59), wood chips partially hydrolysed by a small quantity of dilute sulphuric acid, are defibrated mechanically as usual, and the resultant pulp mat pressed wet at high temperature to form a board having a specific gravity of 1·0 and which can be nailed. Hardwoods give a somewhat better product than softwoods – which seem to confirm the Italian experience of having stronger boards with woods rich in lignin, which most of the American hardwoods are, in comparison to softwoods. Further research in the U.S.A. has disclosed the superior plasticising properties of *partially hydrolysed* wood substance rich in lignin, although by itself lignin has little of it (60).

It would, however, appear that the use of soda ash or lime and sulphur instead of sulphuric acid is an important economic consideration in favour of the Italian Xilon process for application in a country like India. In the forest region of Eastern India, however, enough lime is locally available, and the mineral oil deposits of Assam are providing considerable supplies of sulphur to-day, as already indicated in an earlier paragraph. The Xilon process is claimed not only to permit of a flexible plant being installed, but also to produce a "paper-type" pulp from lowgrade hardwoods at a much less cost than the usual chemical pulping processes. Technical assistance in the form of actual demonstration at a small cost and of supply of designs of the plant are obtainable from the firm Messrs. Azienda Brevitti Industriale, Milano, the originator of the process. A chipping machine, a steel digestor, a revolving stone grinder or attrition chamber and a hydraulic press are the essential equipments, all of which can now-a-days confidently be expected to be made at Calcutta from the designs supplied. This wet process thus appears to be an admirably suitable one for application in Eastern India, in that it automatically offers an opportunity of investigation into the pulping qualities of the mixed hardwood waste for paper, the desirability of which has already been emphasized, while serving the immediate object of turning the waste to account through the channel of board manufacture.

Coming to a consideration of the dry processes, the essential feature in all of them is the use of a binder of some sort. The development of the dry bonding processes owed its origin to the fact that hard and soft (insulating) boards hitherto made by wet processes without binders left a gap in the range of organic materials – a gap ranging between specific gravities of ·4 to ·8 where materials of really "woodlike" character were lacking. The first successful commercial process is the manufacture of the so-called "*homogeneous wood*" or *Homogenholtz*, that came into operation in Switzerland in 1938–39 (66). In the beginning the wood substance had to pass through a wet phase in one of the then known defibration processes, and thereafter dried in the pulp stage before being mixed with binder, but later dry wood shavings and particles could be directly mixed with binders and *pressed dry* to form boards (and even *beams*) that were stronger than the usual natural woods in all directions except along the grain.

But it was not possible to obtain the uniformity of a board built up from fibres in the wet processes, in one from ordinary wood shavings. This difficulty was obviated by the construction of special mechanical disintegrators to break cordwoods into shavings of predetermined sizes and shapes.

A modification of this process came out in 1945, turning out boards under the name "*Wonderboard*", which was again due to a Swiss Engineer (58). In this process the resultant board has three layers, the two outer thinner layers consisting of shavings of uniform shape and size to impart a pleasing appearance, while the thicker core (60–80% of total thickness) being made up of random wood waste splinters specially ground and screened to specified lengths and thickness. Due to the random grain orientation in the core wonderboards are singularly free from tendencies to warping. The undersized particles of wood or *dust* is used as fuel for running the plant. Any species of wood can be used and mixed species often have an advantage in producing striking patterns on the faces.

Since the termination of War, several other dry processes, all, however, essentially the same in principle as those described, have been evolved, particularly in the Central European countries and in the U.S.A. Although the best qualities of dry bonded boards require uniformity in size and shape of wood particles used, random collections of planer or other forms of wood shaving and even saw-dust are to-day widely used to produce a variety of the commoner types boards in demand (12, 28, 48), including strong floor boards and a variety of smaller products (66). To-day there is no doubt that the dry processes are capable of producing from lowgrade wood wastes wall-boards superior in strength and other properties, not only to boards made by wet processes, but also to many of the utility classes of timber. These "synthetic boards" are now being more and more used for most of the applications where wood is used, often doing a better job than lumber (28).

But it has been the general experience in most of the western countries that the binder is often the costliest item of raw material in the dry processes of manufacturing fibreboards. The *phenolic resins* are to-day almost universally used throughout the western countries (12). Except for special uses, therefore, this usually places the cost of "synthetic boards" out of the general wall board class. In some cases the producer of such resin-bonded boards actually finds himself in the chemical business of manufacturing the required resins economically, rather than keeping to his own business of wood processing (49). Therefore, the great limiting factor in the application of the dry bonding processes in India would at once appear to be the cost and availability of the phenolic resins which have to be largely imported to-day. Recent investigations at Dehra Dun (48) have, however, indicated that the cost on, and consumption of phenol formaldehyde resin can be greatly reduced by the use of groundnut protein formaldehyde, and that two parts of this more easily available material with one part of P.F. resin constitute a satisfactory binder for most of the utility varieties of fibreboards that are in demand in India at the moment. Again, in a process recently developed in the Polytechnic Institute, Brooklyn, New York (49), using small amounts of a cheap chemical (*not resins*) as an "activator" to increase the thermoplastic properties of lignocellulose in wood particles, including planer shavings, saw-dust, etc., or in defibrated lignocellulosic pulp, very satisfactory boards approaching in all respects resin-bonded boards have been made. The boards can be nailed, screwed, sawn, drilled and otherwise worked with the usual wood working tools in the same way as lumber. The use of cheap chemicals as "activator" has lately been confirmed by another American board manufacturer (42). But unfortunately, in neither instance, the name or names of such chemicals have been disclosed. Yet another board manufacturer in the U.S.A. has recently claimed to have used a fungus or wood rotting organism (in fact "a finely ground slurry of pre-rotted wood") as a cheap and satisfactory binder to produce a board under the trade name *Gossite* (65) with an unusually hard surface, densities of ·55 to ·90

and with a modulus of rupture between 3,000 and 6,000 p.s.i. – a material that is believed to be potentially competitive with lumber in price. But here again the name of the fungus or disintegrating organism that forms the basis of the binder has not been disclosed. All these instances, however, seem to indicate that the phenolic resins are not essential for the manufacture of synthetic boards of average quality and that cheaper substitutes would be known to us before long ; but meanwhile a start can as well be made with groundnut protein formaldehyde mixed with half the quantity of phenol formaldehyde resin, recommended by the Forest Research Institute, Dehra Dun.

The great advantage of the dry processes is the smaller energy and steam consumption (against that required for digestion and defibration in the wet process), *greater facility for using waste wood of all descriptions and the greater possibility of operating economical plants of small capacity* (66). Thus in the smallest scale operation, once the wood is mechanically disintegrated into shaving or particles, the mixing with binder, spreading on trays, etc., can be manually operated till the pressing stage. So a *mechanical disintegrator* and a *hydraulic press* are the essential equipments which represent most of the capital investment, and which, with a little difficulty can perhaps be made in India, from designs supplied by a chemical engineer.

The present price of hardboards of the Masonite type is about As -/8/- per square foot at the minimum, for 3/8 inch boards – which works out to Rs. 16 per cubic foot, i.e., very near to that of the scantlings of best C.P. Teak (*Tectona grandis*). It can be shown that, with the present rates of logging and extraction of wood in the forest, handling and of rail transport, and assuming the royalty payable for the waste at even say 10 times that of fire-wood at cartload rate already referred to earlier, the value of the wood substance is at least trebled. Thus there is nothing to doubt the economic prospects of board manufacture in this part of India, particularly in view of the rising demand of the end product. And as complicated equipments and highly skilled wholetime technicians are not required for operating small decentralized plants, this would appear to be the most desirable avenue of profitably utilizing much of the wood waste, locally by the *wet* and generally by one of the dry processes hitherto indicated. It would not be out of place to record here the recent observations of the F.A.O. Sub-committee on Wood Chemistry on the question of utilizing lowgrade wood waste in the forest, in their fourth meeting at Brussels, 1949 (8) : "that the manufacture of fibreboards in small decentralized plants is to-day technically desirable and feasible under a wide range of conditions, and that this development opens up the possibilities of a widespread utilization of tropical and sub-tropical hardwood wastes of mixed species".

PRODUCTION OF SUGARS, ALCOHOL, ETC., FROM WOOD WASTE

The acid hydrolysis of a cellulosic material such as wood results in the formation of carbohydrates, mainly hexose and pentose sugars. The hexose sugars are fermentable with brewers' or bakers' yeast (*Saccharomyces*, sp.) to yield ethyl alcohol. The fodder yeast (*Torula*, sp.) on the other hand, utilizes both hexose and pentose sugars. The two well-known processes of hydrolysis, viz., the *Scholler* or dilute Sulphuric acid process and the *Bergius* or concentrated Hydrochloric acid process (27) were both used in Germany during the recent war mainly to produce fodder yeast as cattle food. The *Scholler* process, which is considered preferable on technical grounds (26), has since been thoroughly investigated in the U.S.A., particularly for the production of ethyl alcohol, and eventually perfected into what is now known as the "Madison wood sugar process" (36). The economics of wood hydrolysis is still considered very generally doubtful (26, 27, 46), especially in countries where an adequate supply of molasses is available for producing all their requirements of ethyl alcohol, or where opportunities for synthetic production of alcohol from petroleum refineries exist. Again, in predominantly agricultural countries like India the introduction of fodder yeast as cattle food

can hardly be expected to make any headway against the deep rooted prejudice of the conservative peasant in favour of green fodder. To this somewhat depressing economic forecast of wood hydrolysis generally, it must be added that about a third of the wood submitted to hydrolysis is left behind as a solid residue consisting mainly of lignin whose profitable utilization has not yet been possible (26, 46). Although some experts in the U.S.A. (46, 50) claim that the production of crystalline sugars from wood waste at a lower cost than those obtainable from the existing conventional sources is now approaching realization, there is no experimental evidence yet in the form of a commercial undertaking, nor has it been proved that there is no "catch" in the sugars produced from wood hydrolysis in the form of deficiency in vitamins or in other essential biochemical properties (24).

Now, considering that there is already an established and widespread industry for the manufacture of sugars and ethyl alcohol from molasses in India, it can be safely said that there is hardly any scope for an independent "wood sugar industry" ever developing in this country. It may, however, be worth considering as a subsidiary operation in one or other process of chemical wood utilization hitherto suggested, if such an integration eventually proves profitable. Recently a process has been developed in France (63), whereby a *partial hydrolysis* of wood chips in a single operation ("degradation") has been found to yield a proportionately higher percentage of ethyl alcohol than in the conventional processes with successive degradations of wood chips with acid. The process uses a small quantity of dilute sulphuric acid to hydrolyse partially the wood chips in a simple lead lined digester for the operation of which no skilled technician is necessary. The further advantage of the process lies in the fact that the wood chips being only partially hydrolysed would permit of a much more profitable utilization in the manufacture of fibreboards (45) or plastics (60) than when they are completely hydrolysed. If we now recall the Italian wet, or *Xilon* process, of the manufacture of fibreboards, it will at once appear that the partial digestion with lime and sulphur is in effect a partial hydrolysis of the cellullosic content of wood, resulting in the softening of the chips. Now, following the principle of the effect of single degradation in producing a proportionately higher percentage of fermentable sugars, it can confidently be expected that the liquid effluent after preliminary digestion in the Xilon process would be a profitable source of ethyl alcohol. Thus with very few additional and simple equipments, it *might* be possible to obtain a profitable supply of ethyl alcohol as a byproduct in the wet process of manufacture of fibreboards, hitherto suggested.

WOOD WASTE IN THE PLASTICS INDUSTRY

By the early thirtees of the present century, the manufacture of *woodflour* for use as plastic filler developed into a specialized industry using wood waste in many of the Western countries, notably in the U.S.A. (50) and Britain (6). Until recently, however, only certain species of wood, mainly coniferous, were considered suitable as a raw material for plastic fillers. Later researches have disclosed that not only techniques can be developed whereby the species of wood used is immaterial in the quality of fillers obtained (14), but also that the best fillers for high grade plastics are obtainable from the residue of *partially hydrolysed* wood, irrespective of the species of wood used (60). It is now established that the active principle in a good plastic filler is lignocellulose, rather than lignin itself, which, therefore, has so far defied use as such in the plastics industry.

The main obstacle in the expansion of the plastics industry in India is not the availability of fillers but of the binder or "solvent", i.e., phenolic resin which has largely to be imported to-day. The present scanty demand of fillers does not permit the utilization of the forest wastes, as it is readily met from the wood wastes of the various saw-mills and other wood working industries round Calcutta and other larger cities. It would, however, be of interest to

mention here the potentialities of wood wastes alone in the plastics industry, as are indicated by the latest trend of research. It has lately been disclosed by the U.S. Forest Products Laboratory (50, 60) that *lignin* dissolved in organic solvents or suspended in water can be made to react with Hydrogen ("hydrogenated") at elevated temperature and pressure in the presence of various metalic catalysts, to produce various cyclic alcohols, *phenols which show promise as plastic solvents*, complex neutral oils together with a plastic-like residue. Wood waste or chips can also be thus hydrogenated in aqueous suspension to produce soluble lignin decompostion compounds and a cellulose pulp residue. The economics of such hydrogenation operations are not yet known, but it would appear that if these eventually prove to be commercial propositions, they might open up an enormous opportunity of extending the plastics industry in this part of the world, with wood waste as the *only* basic raw material.

General

Before concluding it would perhaps be worthwhile recording here the present trends of thought of wood chemists all over the world with regard to the economic prospects of chemical methods of utilization of wood waste. The sub-committee on Wood Chemistry of the Food and Agricultural Organization of the United Nations, in its fourth meeting at Brussels, 1949, has gone into the latest developments in the techniques of the various chemical wood utilization methods, vis-a-vis their economic prospects in a variety of circumstances (8). They have unanimously held that in order to ensure a reasonable financial return from any undertaking on chemical wood utilization, such should be integrated with one or other of the major wood using industries. Many forms of such integration are to-day successfully operating in various countries, but no one pattern can yet be found to be universally applicable. They have, however, concluded thus : "at least two 'types' of industry, one based on mechanical conversion of wood, e.g., saw-milling, plywood and veneer making, etc., and the other designed to use primarily wood as a source of fibre, e.g., pulp and paper, various types of wall-boards, etc., should be integrated to ensure an overall financial return from such a 'horizontal combinate of forest industries'. Such an integration has been demonstrated to be technically desirable and feasible under a wide range of conditions. Other methods of chemical wood utilization, e.g., destructive distillation, wood hydrolysis, etc., which have found commercial application so as to raise the overall financial yields from integrated operations in certain localities do not, however, lend themselves to the same type of general application as those indicated in the first group".

Following the above principles, it would be advisable and perhaps feasible to integrate small decentralized plants for the manufacture of fibreboards hitherto suggested as the most suitable method of chemical utilization in this area at the moment, in the first instance with the existing saw-mills or plywood factories, although they are mostly privately owned. Although the working out of the technical details and overall economics of such an undertaking is essentially the job of a chemical engineer – it rests on the forester to ensure adequate and sustained supplies of wood waste within an economic hauling distance.

The pioneer undertakings, it appears, will nearly always have to be initiated as State enterprises in conjunction with an existing State saw-mill or other wood using industry, in order to demonstrate their economic potentialities to the rather conservative industrialists of our country. But as regards the very highly specialized methods of chemical wood utilization, e.g., manufacture of fertilizers and methanol, the potentialities of which have been indicated earlier in this note, the aid and co-operation of established and enterprising chemical firms (e.g., Messrs. Bengal Chemical and Pharmaceutical Co., Ltd., Imperial Chemical Industries, etc.) would have to be sought for from the very outset.

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WOOD PRESERVATION IN INDIA

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From time immemorial, timber has been the chief structural material. It was used even by the primitive people for building houses, for making furniture, for shaping tool handles, and for building river and sea craft. The main causes for the popularity of timber are its easy availability in a form ready for use, its light weight, and its ease of working.

The world's[1a] forests cover an area of 9,125 million acres, almost one-third of the earth's surface cf. Table No. 1. Of this, 35 per cent is covered by softwoods, 15 per cent by temperate hardwoods, and the balance of 50 per cent by the tropical hardwoods[1b]. These forests yield about 1,060 million tons of timber each year. Taking the population figures of the world as 2,166 million, it means that on an average, 24·5 cu. ft. of timber per caput can be made available. But the actual consumption of timber for structural, chemical, and industrial purposes ranges per caput from 63·5 cu. ft. in North America to 1·1 cu. ft. in the Middle East[1b]. Two main causes for such a great variation in the consumption of timber are (1) the uneven distribution of the forests of the world – Canada 75 acres per caput and Syria 0·075 acres[1b] (2) the preferential demand (85%) of the softwoods compared to hardwoods for industrial uses[1b]. To this may be added the lack of modern equipment in the backward countries. Thus the amount of timber consumed per caput has come to be ragarded as the yard stick of civilization, or better still, the standard of living.

With the increased use of timber for various purposes, the ancient people knew that not all woods gave satisfactory service. They found out that quite a large number of species of timbers got deteriorated on account of attack by fungus, insects and marine organisms. The chemical preservation of timber, therefore, was given serious thought even during early times. References are to be found to the use of bitumen by the ancient Egyptians about 2–4,000 years back to preserve their coffins and wooden dowel pins[2a] ; of garlic boiled in vinegar to preserve wood from attack by worms[2a] ; of oil of cedar to preserve wood against worms and fungi[2a] ; and of wood tar to paint the boat used by Erik the Red to go to America in (1025–1033)[3a]. In the Saga of Fritjof the Bold (750 B.C.) his ship is called "Tarred Wind Horse"[3a]. Mercuric chloride was used to protect wood from decay in 1705[4a] ; copper sulphate was used later on for the same purpose. In 1805 cheap and non-durable woods like fir were said to have been impregnated with distillation products of chips of teak[2b] a timber of reputable natural durability.

Wood Preservation as a science was developed by the British Navy to protect its ships from dry rot. About 1832, Kyan (a chemist), the British Admiralty Medical Chief, Sir William Burnett, and a coal tar expert Bethel, developed processes for the impregnation of wood[3a]. While Kyan used mercuric chloride and Burnett zinc chloride for dipping timber in a solution of the above chemicals, Bethel treated timber with creosote under pressure. A novel method of treating both green poles and living trees was developed in 1837[4a] by Dr. Boucherie using water soluble inorganic salts such as copper sulphate and zinc chloride. Another method employed in the very early days consisted of carefully charring timber surface so that the charcoal formed thereby, being devoid of any food material, repelled wood destroying organisms. In addition to this, it was observed that a certain amount of wood-

tar was produced during this process, which protected the timber. "On the destruction of the Temple of Diana at Ephesus, it was discovered to have been built on charred piles, and at Herculaneum charred wood 2,000 years old was found in good preservation[2a]".

TABLE No. 1

Table showing distribution, area, yield and consumption per caput of World's timbers

	Europe other than U.S.S.R.	U.S.S.R.	Middle-East and North Africa	North America	Central and South America	Africa excluding North Africa	South and East Asia	Pacific Area	WORLD TOTAL
1. Population (in millions) ..	392	178	98	143	130	115	1,099	11	2,166
2. Forest Area (in million acres)	330	2,400	102·5	1,587·5	2,037·5	1,280	1,250	135	9,125
3. Area per caput (in acres) ..	0·75	13·5	1	11	15·75	11	1	12·25	4·25
4. Cut: Total timber (in million cubic feet)	10,872·4	9,248·6	176·5	13,837·6	6,283·4	1,588·5	10,590	353	52,950
5. Per acre (cubic feet) ..	32·9	3·85	1·78	8·72	3·08	1·24	8·47	2·61	5·8
6. Per caput (cubic feet) ..	27·7	51·95	1·8	96·76	48·33	13·8	9·64	32·09	24·44
7. Consumption: Industrial Total timber (in million cubic feet)	6,389·3	3,812·4	8·25	9,213·3	11,825·5	423·6	3,338·8	211·8	24,710
Per caput (cubic feet) ..	17·65	21·18	1·06	63·54	1·06	3·53	3·53	17·65	10·59

By and by, interest in wood preservation extended to France and Germany, and later on to U.S.A. The greatest impetus to Wood Preservation, was given by the invention of the steam engine. The engineers Stephen, Brunell, etc., who laid the first railway track, used treated sleepers employing Kyan's Process[3b]. Now over two-thirds of the World's rail roads are laid on wooden sleepers. Nearly 180 million sleepers produced out of 21 million tons of round wood, are used annually for renewals by all the railways[1c]. Another important use of treated wood is in the form of 'Pit Props'. About 21 million tons of timber in the form of pit props are needed annually, to support the world's coal mines alone[1c]. The telephones, telegraph, electric light and power companies, and the ship building, railway coach building, etc., industries are some of the largest consumers of treated timber. Further, with the gain of precise knowledge of the behaviour of timber under variations of temperature, humidity, and loads, and the development of laminated timber for long span bridges, aeroplane hangers, roof trusses, etc., treated timber is in greater and greater demand every day. The science of wood preservation itself, in recent times, has made such great strides that a large variety of preservatives with special properties to suit special demands are now available. New processes of timber treatment using high vacua, and very high pressures[5] of the order of 1,000–2,000 lbs./sq. in., and new methods of not only of quick drying, but also incising timber in bulk so as to make refractory timbers treatable by special treatments called vapour drying process, are also available. In addition, timber can be impregnated and also painted over, so as to increase its resistance to fire. By these methods it is now possible to increase the service life of timber structures to 5–10 times their normal life. Wood Preservation is thus a well established industry in all the civilized countries. Its economic importance and its

indirect effect on forest conservation is accepted. It is practised in U.S.A., Canada, U.K., France, Germany, Sweden and other European countries, U.S.S.R., Africa, New Zealand, Australia, Malaya, Japan, China and India. But full details of its progress are not available, except for a few countries, on account of conditions consequent on the second World War.

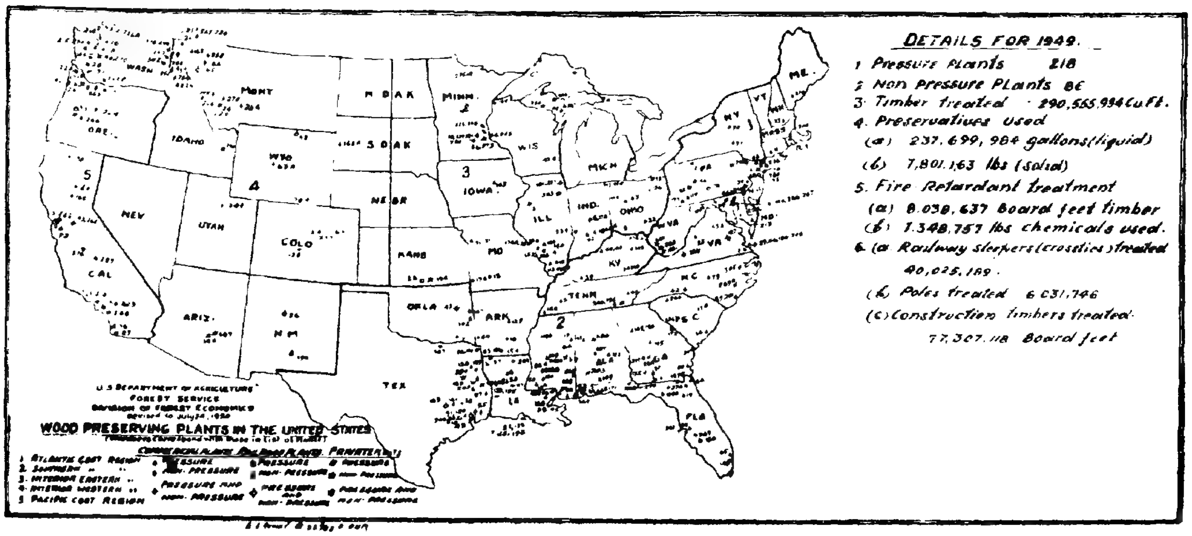
PROGRESS OF WOOD PRESERVATION IN U.S.A.

America with its 637 million acres of forest land has an estimated annual yield of 11,296 million cubic feet[1d] of timber. Wood Preservation in that country is reported to have been started as early as 1716 by Dr. William Crook[4b], to protect ship planking from shipworms and decay. The preservative used consisted of "one part of Oyle or spirit of tar"[4b].

It was in the nineteenth century that the treatment of timber assumed practical importance in the U.S.A. when J. B. Card (1906)[4c] patented a one-movement impregnation with a mixture of zinc-chloride and creosote. The progress of this industry from this time became quick and spectacular, and at the moment is one of the major industries in U.S.A. It is well organized throughout the country and has an Association of its own which annually publishes in its proceedings data on the progress of the industry. The data[6] show that for the 41 years period between 1909 and 1949, the equivalent of 110·3 billion board feet of timber was treated. Taking the average increase in life of timber as a result of preservative treatment as 5 times, this 110·3 billion board feet is equivalent to 551·5 billion board feet of untreated timber. Therefore, the timber saved during that period is 441·2 billion board feet or 10·8 billion board feet a year. Assuming an average cost of \$30 per 1,000 board feet, the aforesaid timber saved is worth \$13·2 billions or a daily saving of about \$884,000.

In U.S.A. there are 218 companies owning pressure treating plants and 87 owning non-pressure treating plants cf. Fig. 1[7]. The capital cost of these plants is estimated at \$200 millions after deducting depreciation costs[6]. About 25,000 workers are employed in these plants and their pay comes to about \$70 millions a year[6]. Tables 2 and 3 (*vide* App.) show the quantity of timber treated and the preservative consumed in the peak years 1929, 1949 and for the period between 1909–1949[6]. It is understood that a target of treating annually 410 millions cubic feet of timber is aimed at. Further, it is also indicated that the men in charge of the rail roads feel that the average life of treated timber can be increased from the present figure of 15 years to 40 years[6].

FIG. 1.



The 1949 figures show that in U.S.A. about 6 million tons of timber were treated with preservatives. To achieve this, 240 million gallons of creosote and other allied types of preservatives, and 4 million lbs. of dry preservative salts were used[7a]. The same year 8,038,637 board feet of timber were given fire-retardant treatment consuming 1,348,757 lbs. of inorganic dry chemicals[7b].

PROGRESS OF WOOD PRESERVATION IN GERMANY

The forests of Germany cover 26 per cent of the land area[1c]. They yield 28 million tons of timber per annum[1c]. Total sawn timber per year is said to be 1412 million cubic feet[8].

Wood Preservation in Germany started in the year 1838[2b]. The timber treated at that time was mainly for railway sleepers. Soon the necessity of treating telegraph poles was realized and the Boucherie Process was adopted. Between 1860–1910, 7,000,000 poles were treated[3c]. In 1907, 90 per cent of the poles used in Germany were impregnated[3c].

There are about 35 major pressure treating plants and about 60 small pressure treating plants in Germany[8]. The principal treated product in Germany is the railway sleeper – 4 million[8]. The following is a rough estimate of timber treated in Germany each year[8].—

Cross ties (Railway sleepers)	21,000,000 cu. ft.
Miscellaneous timber	8,750,000 ,, ,,
Telephone poles	3,500,000 ,, ,,
Electric transmission poles	875,000 ,, ,,
Mine timber	1,750,000 ,, ,,
Total ..	35,875,000 cu. ft.

Till 1938, creosote was the chief preservative used in Germany. Other preservatives used were.—Copper sulphate, zinc chloride, sodium fluoride, Basilit (89% sodium fluoride and 11% dinitrophenol-aniline). After 1938, strict control of creosote for war purposes resulted in the use of a water soluble preservative particularly, a composition of Governmental formulation, called "Flanax"[8].

It has to be recorded that, in the first-half of the 20th century, the impetus to the use of timber for all structural purposes and the development of preservation technique in the world were largely due to the intensive fundamental work done in Germany. Later on, America entered the field. America can now be considered to be leading in all aspects of timber research in the world.

PROGRESS OF WOOD PRESERVATION IN SWEDEN

Sweden is a comparatively small country. Her land area is 107 million acres[1f]. Her forest area is 58 million acres, i.e., about 50% of the total[1f]. These yield 4,553,000 tons of timber annually[1g].

Sweden is endowed with abundant supplies of natural arsenic ores. Therefore, a preservative Boliden salt comparable to Ascu was developed in Sweden in 1936. The quantity of the preservative used and the corresponding amount of timber impregnated with it for the years 1936–1947 are 17,248,000 lbs. and 48,235,400 cu. ft. respectively[9].

The Swedish State Railway has impregnated more than 3 million sleepers with Boliden salt since 1940[9]. In 1947 alone 1·2 million sleepers were treated. The State Telegraph Department impregnated 800,000 telephone poles since 1940 of which 200,000 were treated

during each of the last two years[9]. Apart from railway sleepers and poles other important uses to which treated timber is put are piles, bridges, mine props, fence posts and house building.

HISTORY OF WOOD PRESERVATION IN INDIA

Ancient period—The civilization of India dates from about 2,000 B.C. There are very many references in old writings to the effect that timber was used by the ancient people for various purposes. The words 'katcha' (immature) and 'pukka' (mature) in Hindi and 'Chava' (mature) in Telgu indicate that from early times people realized the difference between mature (heart) and non-durable (sap) wood. During the excavation of 'Bulandi Bagh' near Patna it was discovered that old wooden walls, wooden palisade, and wooden drains[11] were in a fairly good state of preservation[10]. It is regrettable that these timbers have not yet been identified. Again, there is a reference to *Cedrus deodara* in the "commercial timbers of India" by Pearson and Brown that "Stewart quoted by Gamble, mentions the pillars in a mosque at Srinagar in Kashmir which after 475 years were quite sound". However, we know that even durable timbers like sal, teak, *Mesua*, etc., do not last for more than a few decades when buried in the ground. It is, therefore, to be concluded that these timbers which have been in the ground for over 20 centuries at Pataliputra from the Maurya period onward must have been given some type of preservative treatment to protect them from the hazards of decay and insect attack. Unfortunately, very little information is available as to the methods and specific compositions employed by our ancient people to preserve timber. A serious attempt is now being made all over the country to collect information that may be available on the subject from our old records, and by analysis of timbers found buried in the ground during excavations.

Present position—Wood preservation on the lines followed in the West appears to have been introduced in India about the middle of the 19th century. The earliest attempts in this direction were by the East Indian Railway which erected a creosoting plant at Bally near Howrah (1854)[12a]. In 1865, the M. & S.M. Railway treated green timber near Palghat by the Boucherie process using copper sulphate and afterwards converted them into sleepers[12b]. During the same period, a Burnettizing (zinc chloride treatment) plant appears to have been erected at Kotri, on the Indus[12c]. Sleepers so treated of *deodar* and *chir* pine were laid out on the Sind, Punjab and Delhi railway lines. Another interesting process called the Haskinizing or Vulcanizing was tried by the B.B. & C.I. Railway[12d]. The principle involved in the process is to coagulate albuminous food materials by heating green pine timber in an enclosed cylinder to a temperature of about 95°C. by passing compressed hot and moist air. It was claimed that during the process some turpentine and resinous acids and other toxic materials were formed which protected timber against fungi and insects. About 5,000 sleepers so treated were laid on the lines, chiefly in the Bombay and Broach Divisions. While the results were rather unsatisfactory, in the Broach line due to heavy termite infestation, they were reported to have been reasonably good in the Bombay line. In 1878, the Government of India deputed Dr. Warth to make a detailed enquiry into the possibility of treating coniferous woods of the Himalayas so as to render them suitable for use as railway sleepers[12a]. His valuable proposals were, however, not given effect to.

Large scale imported sleepers appear to have been laid out on a number of Indian Railways early in the 20th century. Some of these consisted of pine sleepers from U.K. and Baltic countries. These were said to have lasted from 7–12 years[12c]. About 160,000 Douglas fir sleepers, pressure treated with creosote, were also imported from Canada ; but the results on the service life of these sleepers were not satisfactory. The main defects reported were poor spike holding, cracking and splitting and rail cutting[13a].

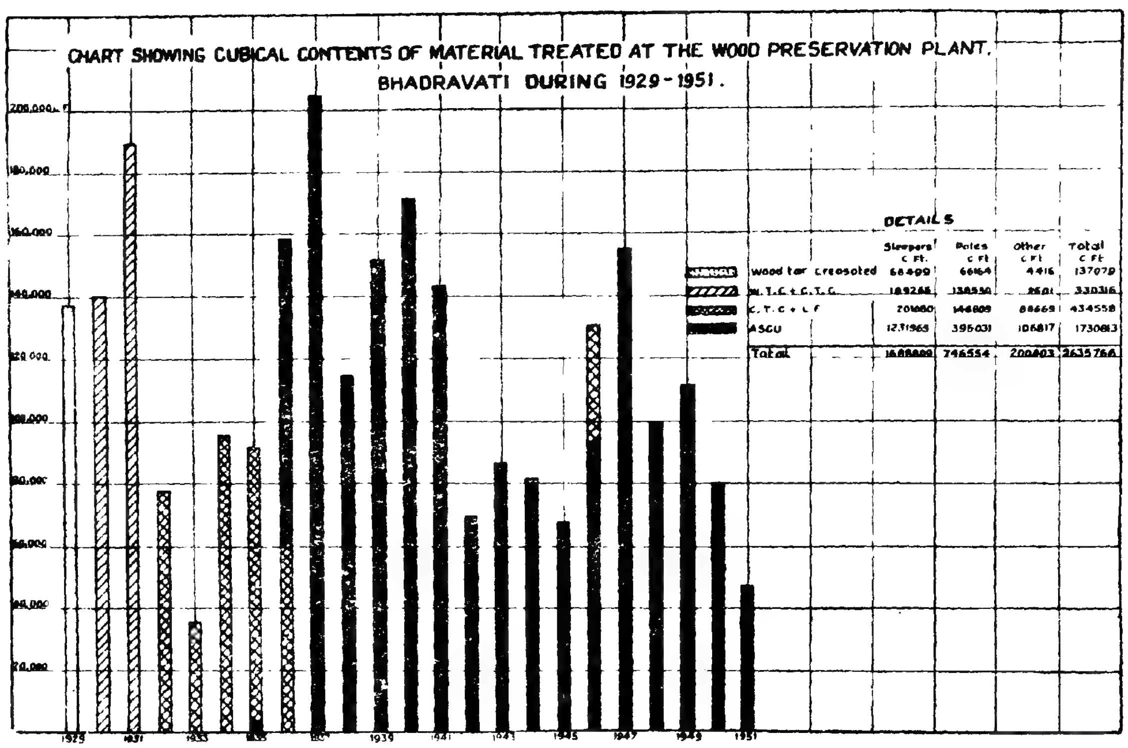
Wood preservation on scientific and modern basis was introduced in India by Sir Ralph Pearson of the Indian Forest Service in the year 1908. In view of the valuable pioneer work he did during the course of his service at the Forest Research Institute, Dehra Dun, he is entitled to be called the Father of Wood Preservation in India. Pearson started work, in earnest, by conducting a series of tests on the efficacy of various preservatives, using timbers of all grades of hardness and durability, on a laboratory scale[13]. These specimens were then laid in the ground along with untreated specimens. Another set of important experiments which he started thereafter was the treatment of nearly 9,000 sleepers of various species for durability trials on the India and Burma Railways[13]. Some of the preservatives he used consisted of Powell's solution, Avenarius carbolineum oil, zinc chloride protected by a coat of green oil, and solignum and/or liquid fuel. Most of these sleepers were treated by the hot and cold bath process and a limited number were treated at Digboi in Assam by pressure process using green oil and liquid fuel. He also arranged for treatment of about 100 sleepers under pressure with creosote in England[13]. An exhaustive summary of the results of these sleepers after about 24 years service is given in I.F.R. Bulletin No. 85 (1934). While some of the sleepers gave an average life between 15–20 years, others gave between 7–12 years. These results can be taken as satisfactory considering the difficulties involved in carrying out experiments of this nature in those early days.

The next stage in the development of Wood Preservation in India goes to the credit of S. Kamesam. His early experiments consisted in the determination of the natural durability of various species of timbers. These experiments have now yielded, after a period of 25 years, valuable results on the durability of about 200 species of Indian and Burma timbers. He then turned his attention to the development of a suitable wood preservative of the water soluble type and succeeded in discovering the "Falkamesam" preservative in collaboration with Prof. Falk of Germany. After about 2 years, he further improved upon Falkamesam. The new preservative Ascu was developed in the year 1933. This brought in international recognition of the good work done on Wood Preservation in India. Being essentially an Engineer, he also designed various structures using treated timbers, and thus opened a new line of research in Timber Engineering in India.

A new orientation was given to work on wood presevation by Narayanamurti and his co-workers. D. Narayanamurti, V. Ranganathan and others investigated in great detail the suitability of various creosotes for wood preservation purposes in India[15a]. The work, enabled the Indian Standards Institute to draw up a specification for creosote for use under Indian conditions. Narayanamurti and Purushotham[15b] worked on the permeability of air in several timber species. The natural fire resistance of 56 Indian timbers was investigated by Narayanamurti and Gopalachari[15c]. Both these investigations are essentially academic in character but the former gives great insight into the treatability of timber and the latter into its protection against fire. Narayanamurti, Purushotham and Pande studied the preservation of green bamboos[15d].

As in other parts of the world the credit for the establishment of Wood Preservation Industry in India goes to the Indian Railways. One of a series of steps taken by the railways in this direction was the setting up (1926) of the first commercial pressure creosoting plant at Dhilwan (Punjab) with a capacity to treat about 10 lacs of B.G. sleepers per year working 3 shifts a day. The species of timbers treated at this plant consist of the Himalayan softwoods, *chir*, fir, *kail*, *deodar* and spruce. Of late *chir* is the only species treated on a large scale. Immediately thereafter another creosoting plant with a capacity of about 4·5 lacs of M.G. sleepers per year, also working 3 shifts a day, was set up at Naharkatiya in Assam. The first privately owned commercial plant to treat timber was set up by the Assam Railway and Trading Co. Ltd., Margherita. This plant has a capacity to treat about 8 lacs of sleepers

a year and was originally meant to supply treated timber for their railway. However, this plant also treats timber for other uses. The Assam plants mainly treat the *hollong* and *hollock* species. Another medium sized plant for treating sleepers for the Mysore Railways using the indigenous wood tar creosote was started in the year 1928 by the Mysore Forest Department, at Bhadrawati. But due to heavy corrosion trouble the use of wood tar creosote was abandoned and coal tar creosote substituted. Again, after the development of Ascu, a preservative which leaves a clean and a dry surface on treated timber, the Bhadrawati plant started using Ascu for the treatment of transmission poles as well as sleepers cf. chart [16]. While *balagi* (*Pœciloneuron indicum*) species after treatment is used as poles, *dhuma* (*Dipterocarpus indicus*) species is used after treatment as sleepers. Very recently the Bhadrawati plant has gone back to treatment of sleepers with coal tar creosote. An idea of the business dividends in wood preservation, can be got from the report of the Mysore Forest Department. "The Forest Research Laboratory, Bangalore and some of the offices and residential quarters at Bhadrawati were financed from the reserve funds built up by the plant"[16]. Following the footsteps of the Mysore Forest Department, the Travancore Forest Department set up 3 pressure treating plants using Ascu preservative. These plants treat mainly teak poles obtained from thinnings for use as transmission poles and other species including bamboos for building purposes. Details regarding the plants now working in various parts of the country are given in Table No. 4 (*vide* App.).



Another Government Department that has, in recent years, encouraged timber preservation is the Defence Organization. Timber for ammunition boxes, plywood for pontoons, bamboos for tent poles, and various wooden tool handles are all treated. Generally, copper-naphthenate in white spirits or in ammoniacal emulsion is used ; the dipping method is followed.

An interesting method of treating timber in green condition is known as the Osmose process. This consists in debarking freshly felled poles and applying a thick coat of a water soluble preservative on the surface. These poles are then closely piled to prevent quick drying of the timber. In the course of about 3–4 months the preservative penetrates to a satisfactory depth into the timber. Such treated *Pinus insignis* poles, about 2,000 in number have been treated at Kodaikanal[17]. They have given about 12 years life cf. plate No. 1.

PLATE No. 1

Osmose treated *Pinus insignis* pole at Kodaikanal after 12 year's service.

In this country about 4–5 million cubic feet of timber are treated for sleepers, poles, piles, constructional purposes, packing cases, tool handles and tea-chests. About 1·75 million gallons of oil type of preservatives and 1·5 million lbs. of dry salts are used annually.

Another important development, is protection of timber against fire. Work on the natural resistance to fire of about 56 timber species, as already mentioned, is reported in I.F.R. Bulletin No. 118 (1943). Suitable compositions both for painting and impregnation of timber so as to increase its resistance to fire were recently developed at the Wood Preservation Branch of the Forest Research Institute. Interest in fire-proofiing of timber is shown by the railways, the mining and the cinema industries. Again it is the railways that have given a lead in this direction. The Central Standards office of the Ministry of Railways gave chemicals worth Rs. 6,000 to treat 400 *chir* and 166 *sain* sleepers with a fire-proof-cum-antiseptic composition developed by the Wood Preservation Branch of the Forest Research Institute. The treatment of the sleepers is now over, and their performance will be watched on the track.

At present there are three centres where laboratory work on wood preservation is carried out in India, viz. – The Wood Preservation Branch of the Forest Research Institute, Dehra Dun, the Technical Development Establishment (Lab.) of the Defence Organization at Kanpur, and the Forest Products Laboratory at Bangalore. But the main work on the development and testing of preservatives, and training of technical personnel in the science of wood preservation is done at the Forest Research Institute, Dehra Dun.

[*to be continued*].

CHLOROPHYLL FOR COLOURATION OF *VANASPATI*

S. V. PUNTAMBEKAR AND P. RAMACHANDRA RAO

Chlorophyll, the green colouring matter of leaves, has been recommended by us as a suitable dye for colouration of *vanaspati*[1]. The details about the process and other aspects of colouration have been discussed in subsequent publications[2]. Chlorophyll, unlike most other natural or synthetic dyes, is not only non-toxic but is actually regarded as a catalyst for human metabolic processes. Berkmann and Berkmann[3] state "It is the most powerful catalyst in the world if administered either orally or intravenously to human beings and will act as oxidation catalyst in metabolic processes of the human body. This is of utmost importance especially for aging organisms, since pathological changes such as arterio-sclerosis, diabetes, obesity, etc., are due to the slowing down of the rate of oxidation in the cell. Chlorophyll, the life-giving substance, is probably the answer to the prayer for prolonging the useful span of life". Further it has been also discovered that chlorophyll has an ability to act as body and breath deodorant[4]. In fact in recent times, especially in America, chlorophyll is entering the composition of several medicinal and toilet preparations and is also being consumed in the form of tablets for breath-deodorant and tonic purposes. In this connection it may be mentioned that from ancient times, according to the indigenous system of medicine, plant greens have been considered to possess tonic properties and have been used for the purpose. Even so, certain objections have been raised against colouration of *vanaspati* in general and the use of chlorophyll for the purpose in particular and here we propose to meet these objections in detail.

In a recent article[5] on adulteration of *ghee*, Subrahmanyan and co-workers of Mysore have discussed the problem of colouration of *vanaspati*. They have given ample evidence, if any was necessary, to show that the *bazaar ghee* in India is now-a-days highly adulterated. It has also been stated that *vanaspati* forms the main adulterant on account of its cheapness and the facility with which it can be mixed up with *ghee* without being detected. Hence, it follows logically that *vanaspati* should either be banned, or branded with a suitable colour to prevent its abuse as an adulterant of *ghee*, if the agelong practice and right of the Indian public to consume one of the most essential foodstuffs, namely pure cow or buffalo *ghee*, is to be protected. But, strangely enough, they maintain that such branding will not ensure the availability of genuine *ghee* in the market as alternative adulterants like vegetable or animal fats, will be utilized instead. They do not seem to have realized that such fats, unless hydrogenated or deodourized, could readily be detected even when added to *ghee* in minute quantities, as was the case before the advent of *vanaspati*, by their characteristic smell and taste. In the case of *vanaspati*, there is no such detector and, therefore, the need for colourization of *vanaspati* becomes imperative.

Subrahmanyan and co-workers have also a case for improving the quality of *vanaspati* so as to make it resemble *ghee*. The reasons pointed out for such a course are the lack of sufficient quantities of *ghee* in our country and the so-called popularity of *vanaspati* products. *Vanaspati*, improved to simulate *ghee* and further fortified with vitamins, it is argued, will fetch an increasing demand as an article of food and thus bring in a reduction in its use as an adulterant of *ghee*. It is really difficult to follow the logic of this argument. If there is more demand for such an improved product more can be produced to meet the demand. If what the authors imply is that there will be less demand for *ghee* and hence no need for adulteration, they are mistaken. Adulteration is practised not merely because there is more demand for *ghee* but mainly because we have a cheap and undetectable adulterant available in *vanaspati* to fill in the pockets of the fraudulent businessmen. If an improved *vanaspati* resembling

ghee is produced, we can be almost sure of further increased adulteration or even wholesale substitution. We do not propose to go into the merits of *vanaspati* as an article of daily food. May be, *vanaspati* has no deleterious effects on human metabolism, but still we shall have to prevent its abuse as an adulterant of *ghee* ; for, apart from the question of affecting the health of the consumers, the adulterated *ghee* invariably affects their pockets. One pays for *ghee* and gets in return only the cheaper hydrogenated groundnut or such other oils. Such state of affairs must cease to exist ; for it is the elementary duty of any civilized Government to see that its citizens get in return what they ask and pay for.

If it is generally accepted that *vanaspati* should be labelled with a suitable colour, we shall have to pitch upon a dye that will approach the ideal, in as many respects as possible. After a thorough examination of the problem, we could suggest the use of natural chlorophyll[1] for the purpose. Colouration with coal-tar dyes for a regularly well-consumed article of diet like the *vanaspati* is likely to bring in certain cumulative deleterious effects. It is always safe to use a natural colour of proved safety. Turmeric, paprika, kamala, annatto, ratanjot and chlorophyll are a few of the important natural colours. Out of these, chlorophyll, has several advantages for the purpose of colouring *vanaspati*. Subrahmanyan and co-workers (*loc. cit.*) admit that *vanaspati* acquires a mild pleasant green colour with chlorophyll. They have expressed, however, certain misgivings about its use. For instance, chlorophyll is almost completely removed by treatment with animal charcoal or Fuller's earth. But the little that remains responds clearly to the fluorescence test, under ultraviolet light. Moreover, such treatment of chlorophyllized *vanaspati* is only academic and too difficult and costly to be practised on any large scale. The cost and labour involved in such decolourization attempts will be sufficient deterrents. Apart from the simple economics of the problem, the complete removal of the pigment with animal charcoal is impossible to be carried out on a large scale without proper equipment and strict scientific control. It is difficult to imagine such a decolourization plant being set up especially against Government vigilance. If the adsorption is carried out on a small scale domestically without proper equipment, animal charcoal is bound to be retained by *vanaspati*.

The experience of Subrahmanyan and co-workers that addition, at 10 per cent level to *ghee*, of hydrogenated fat colourized with 100 mg. per cent of chlorophyll is not usually detected might be due to the use of certain unsuitable grades of imported chlorophylls. We have ourselves had this difficulty with such chlorophylls. No such difficulty has ever been experienced when chlorophyll extracts as prepared by us have been used for the purpose. In fact we have even made the process of colouration of *vanaspati* very simple and economic by the direct extraction of the stinging nettle leaf powder with *vanaspati* itself[2]. The fear expressed by the Mysore workers that such adulterated samples might be mistaken for genuine *ghee* because "at the moment there is no legal bar in the country against colouring *ghee* itself" is clearly unfounded. No one would be foolish enough to colour natural *ghee* simply because there is no legal bar to colouring it. Again, even if the faint colour of a slightly adulterated sample cannot be directly observed, the clear red fluorescence in liquid state of any such sample under an ultraviolet lamp can never be missed or mistaken.

Another "limitation" to chlorophyll pointed out is that "certain brands of chlorophyll contain copper, which may catalyse oxidative changes and rancidity and affect the otherwise stable *vanaspati*". Merely because certain brands of chlorophyll containing copper are being marketed, there should be no objection to using natural chlorophyll which does not contain any copper.

From the discussion above, it is quite clear that the objections raised against chlorophyll are more or less sentimental and imaginary. In fact, we claim that the addition of chlorophyll

to *vanaspati*, is one of the ways of fortifying the fat. The several advantages of chlorophyll for this purpose can be briefly summarized as follows :—

(1) It imparts a natural yellowish-green colour to the fat, the intensity of which can be suitably adjusted to give to the fat an attractive shade.

(2) By the green colour of the fat and its brilliant reddish fluorescence in liquid state under ultraviolet light or even bright sunlight, chlorophyllized *vanaspati* can be readily detected even by the layman when *ghee* is adulterated with even as low as 10 per cent of *vanaspati*.

(3) Even as low an adulteration as one per cent of *vanaspati* in *ghee* can be detected by a microtest for magnesium in chlorophyll.

(4) The pigment can readily be obtained from cheap leafy sources of both forest and agricultural origin.

(5) Unlike some other synthetic or natural dyes, it has no deleterious effect on human beings, either cumulative or immediate.

(6) In fact on account of its closeness in chemical structure to haematin of blood, chlorophyll is regarded as a tonic[6] and is reported to cure certain cases of anaemia. It is also reported to have vitamin-like activity[4]. Berkmann and Berkmann (*loc. cit.*) state that "it is the most powerful catalyst in the world".

(7) Chlorophyll products are attaining prominence for internal consumption as breath deodorants. For this purpose, they[8] are reported to have been sold in America during last year to the extent of several million dollars.

(8) The presence of carotenes in the natural chlorophyll extracts from leaves should be an added advantage in that they are provitamin A.

(9) It will not be economic to attempt to decolourize the chlorophyllized *vanaspati* for fraudulent purposes on any large scale.

(10) A rapid, economic and simple method has been developed for colouration of *vanaspati* directly with the leaves of the Indian stinging nettle without resorting to the isolation of chlorophyll extracts. There is absolutely no possibility of copper entering into such extracts.

It is thus clear that chlorophyll in *vanaspati* would not only effectively prevent the abuse of *vanaspati* as an adulterant of *ghee* but is also expected to fortify the fat. While the richer sections of the people get pure *ghee* and pay for it, the poor man also gets *vanaspati*, enriched with chlorophyll "the life-giving substance". What then stands in the way of chlorophyll being utilized for colouration of *vanaspati* ? If anyone is thinking seriously of colourizing *vanaspati*, chlorophyll is naturally the most suitable colour. No doubt, colouration may affect the sale, production and profits of the *vanaspati* manufacturers. If, for this reason, colouration is not favoured, we will at least be honest in giving up this unnecessary qesut for a dye for colouration of *vanaspati*.

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GRASSLANDS OF SAGAR, MADHYA PRADESH

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INTRODUCTION

A large number of small plateaux, generally denuded of the original forest, occur in the vicinity of the town of Sagar. They bear only thorny scrub and grassland type of vegetation under severe grazing and human interferences, especially fire. The paper describes ecological account of one of the type at village Makronia.

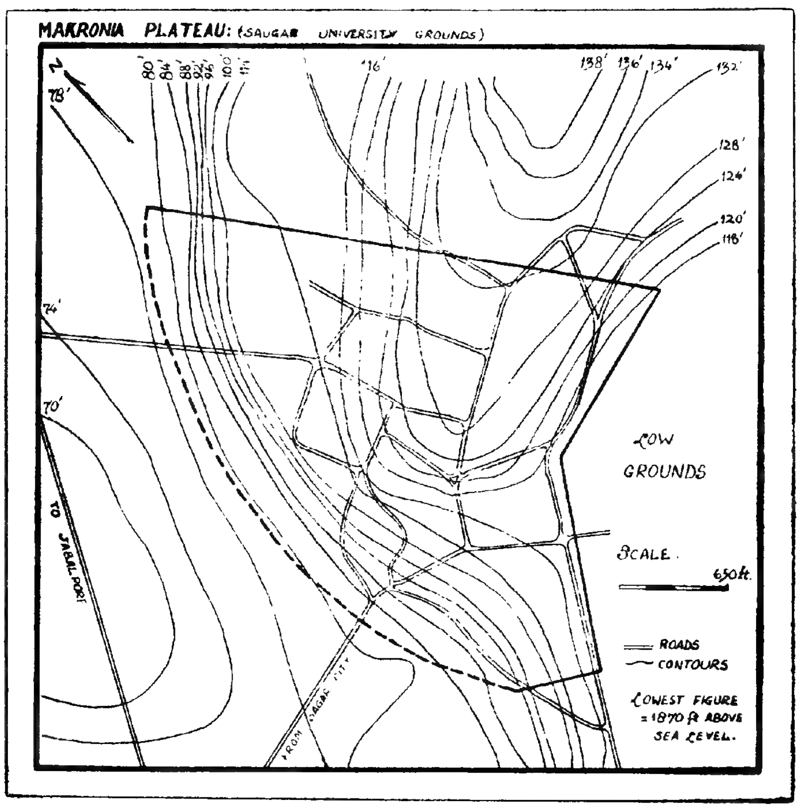

Fig-1. Showing contours in feet. Area studied enclosed with thick line.

The plateau is (Lat. N. 23·50′ ; Long. E. 78·40′ ; Alt. 1,890 feet) about $3\frac{1}{2}$ miles to the east of Sagar town. Towards the north-east it is about $\frac{3}{4}$ mile broad rising into a hillock with a gentle slope towards the south for about five furlongs. The western boundry forms a bulging semicircular ridge with a steep slope of 35 feet and the eastern side describes a corresponding concave ridge dropping into a valley about 50 feet below. It tapers further south into a mile long tail which at places is only 30 yards broad. The valleys all round are cultivated and bear small streams which run towards the north-east. The contour lines on the

top of the platoau run around the hillock at the north-east, but for most of the area these are cut into arcs by the east and the west ridges. The plateau has a gentle slope towards the south with a gradient of 1 in 140 and the east and the west flanks are terraced. (Fig. 1).

GEOLOGY AND SOIL

The plateau lies on the Deccan Trap (of the cretaceous age), and is composed of basaltic rock with thin inter-trappean beds and intercalation of ashes. The rocks are augite-basalt of black to light shades in colour. They are rich in minerals. Under the local climate and being well-drained, sub-aerial weathering leads to the production of a highly argillaceous dark loam '*in situ*'. However, the inter-trappean beds consisting of impure limestones and clays weather into calcareous soil which mixes up with the products of basalt on leaching or by transportation. A subsequent admixture of the weathered products containing iron, calcium and magnesium carbonates, potash, phosphates, etc., and organic matter yields a rich soil. However, locally only a thin immature brown sandy soil in a matrix of gravel accumulate between the out-crops. Water-table in the surrounding lower grounds fluctuates between 2 feet to about 30 feet from the surface.

ORIGINAL VEGETATION

The original vegetation was of a patchy growth of a thorn filled in with grasses, the characteristic species of which are : *Acacia leucophlœa*, *Mimosa rubicaulis*, *Zizyphus rotundifolia*, *Butea frondosa*, *Flacourtia ramontchi*, *Buchanania latifolia*, *Diospyros tomentosa*, *Terminalia tomentosa*, *T. glabra*, *Dichanthium annulatum*, *Themeda caudata*, *Carissa spinarum*, *Celastrus senegalensis*, *Ixora*, sp. and *Tectona grandis*. The whole plateau is now occupied by grasslands.

METHODS OF STUDY

1. *Phytosociological methods*—The study was made by means of quadrats of area 0·02 sq. metre arrived at by species area curve for the grasslands as showed by Kylin and Gleason and quoted by Braun Blanquet (1932). The size of the quadrat, however, for taller community had to be increased to one metre.

The following quantitative estimations were made by laying down the quadrats atrandom :—

(i) *Cover*—Percentage of ground covered by each species per quadrat.

(ii) *Abundance*—Average number of plants of each species per quadrat. Under some circumstances it was not possible to make actual counts, but plentifulness was rapidly estimated and expressed on the following rough scale – r-rare ; f-frequent ; O-occasional ; a-abundant ; Cd-Co-dominant ; d-dominant.

(iii) *Sociability*—Values on a scale of O-5 were given to each species according to its mode of aggregation in each quadrat.

(iv) *Frequency*—Percentage of quadrats showing the presence of species.

(v) *Transects*—Belt transects were studied only on slopes.

2. *Analysis of the environmental factors* – (*a*) *Climate*—Data for rainfall and temperature were recorded by the author, extending over the period of investigation (1947–49).

(*b*) *Soil*—Apart from the texture of the soil carbonates, nitrates, base deficiency (Comber's thiocynate test), water content and organic content were estimated in the soil by the usual tests as described by Misra (1946).

GENERAL CHARACTER OF THE VEGETATION

The vegetation shows seasonal phase, the optimum period of growth for the plants being the rainy season. The optimum temperature and moisture conditions are obtained in the month of July, when the vegetation attains luxuriant monsoon aspect.

After the first rains the almost bare ground starts greening up. The soil is leached or washed down to lower levels. *Scilla indica* comes out first from its previous year's bulb, and *Spermacoce stricta* grow up from the seeds in thick patches. A few species which are able to tide over the hot dry season now spread over larger areas. Other annual species now follow. The grassland growth is found at its best at the end of September and early October when rains have almost stopped and there is abundant sunshine. Most of the species fruit and flower now. With the approach of October many plants begin disappearing. Grasses go dry and other species look brown to dull red.

The number of rainy days during the winter is significant, as it effects growth especially when the temperature is not too low for it, the minimum rarely falling below 40°F. There is an increase in the intensity of biotic factors in the cold season on account of grazing and many grasses very often succumb. Some, however, grow at somewhat protected places which are comparatively moist.

The real hot season starts in about the middle of April when the conditions for plant growth become very severe. The underlying soil loses moisture rapidly. The westerly hot winds set in late in May and continue for a fortnight or so. But the soil being argillaceous and thin, loses most of the moisture by this time making it difficult for plant growth. Hence only a few plants like *Tridax procumbens*, *Amaranthus*, sp., *Bothriochloa pertusa*, *Dichanthium annulatum*, *Echinops echinatus*, etc., are observed along the buildings in the shade or in pits along garden hedges, where they are saved from direct rays of the sun and get comparatively more moisture. The other enduring species adapt themselves to the high temperatures. They get modified morphologically and physiologically by an all round dwarfening of the shoots and slight thickening of leaves.

The ground becomes bare and only small patches of dry, brown vegetation can be seen here and there. With the increase in the velocity of dry wind, sheet erosion of the exposed surface soil may begin. Wide gaping cracks which had appeared earlier in the dry cold season on the deeper and protected soil on the other hand lead to further desiccation.

ENVIRONMENTAL FACTORS

1. *Climate* – (*a*) *Rainfall*—The average rainfall and temperature for each month for the period of investigation are given below :

TABLE I

Rainfall and Temperature during the year 1948

1948	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Total rainfall ..	·65″	..	..	..	·3″	11″	18·6″	17″	5·9″	·8″	6·5″	..
No. of cloudy days	13	2	..	..	..	..	31	31	23	5	13	..
Mean maximum in °F. ..	70·7	77	88·2	102·5	107·5	97·5	85	82·5	84·5	88	74·5	72
Mean minimum in °F. ..	53·5	57	66·5	78	84·5	81·6	77·1	74·5	73·5	71·5	60·5	53·5

Total rainfall for the year 1948 is 61·5 inches.

According to the local Gazetteer of Sagar the highest temperature ever recorded in the town 114·4°F. and the lowest is 39·1°F. and the annual rainfall (average) is 42 inches.

The climate supports a deciduous type of forest since the rainfall is sufficiently high and water is stored up in the soil for absorption by deep rooted plants. But the microclimate of the plateau is xerophytic as far as the grassland growth is concerned.

2. *Physiographic and Edaphic Factors* – (*a*) *Slopes*—The sides of the plateau slope down at an angle of about 35 degrees. They form the north-south boundry of the plateau. The slopes are divisible into three types according to the depth and the character of the soil lying on them. The three types are :—

(*A*) *Calcareous type.*—On the middle part of the slope.
(*B*) *Thin soil type.*—On the southern part of the slope.
(*C*) *Thick soil type.*—On the north part of the slope.

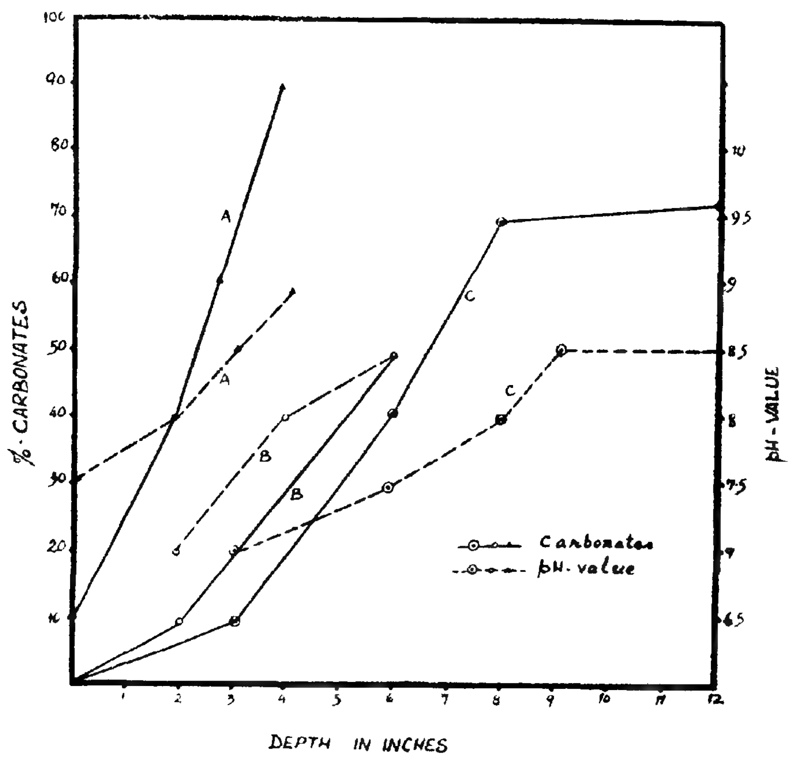

Fig. 2. Variations in carbonate content and pH. value with depth of soil in slopes A, B, and C

Soil Profile—Slope 'A' is maintained immature by erosion and a very thin layer of the soil is found on it. This is supported on rocks consisting of impure limestone. In Slope 'B' the surface consists of a thin deposit of "Colluvial soil" lying on loose boulders of varying sizes, with the interstitial spaces filled up with the same matter. The foundation rocks seem to consist of limestones again. The type 'C' is more or less similar to the type 'B' except

that in 'C' the depth of the upper soil is greater. Data for carbonate content and pH values were taken from different layers of the profiles. The results have been set graphically in Fig. 2. The following table gives the soil data for the three slopes.

TABLE 2

Soil Data of the Slopes A, B and C

Date : August, 1948. Base

Slope	No.	Depth of soil	Texture	Carbonates	Base deficiency	Water content on 15-8-48	pH	Nitrates
A	1 2 3 4 5	1 to 4"	Coarse and fine sand approximately 70 to 80%	8 8 8 7 8	2 2 2 3 3	% 2·4 2·1 2·7 3·5 ..	8 8 8 7·5 8	2 1 2 3 3
B	1 2 3 4 5	1 to 4"	Coarse and fine sand approximately 70 to 80%	0 0 0 1 1	2 2 3 3 3	2·1 3·6 3·8 3·5 ..	7·5 7·5 7 7 7	4 3 4 3 3
C	1 2 3 4 5	4" to 1 ft.	Coarse and fine sand approximately 50%	6 5 3 0 2	0 0 1 .. 0	14 18 .. 12·08 17·08	8 8·5 7·5 8 8	3 4 4 2 3

(*b*) ***Level Grounds***—

a—Deep soil type,

b—Intermediate type,

and *c*—Thin soil type.

In the following table are given texture, depth and chemical nature of the soil of the three types of the level grounds.

TABLE 3

Texture, Depth and Chemical nature of the Soils from the three types of level grounds a, b and c

Date of soil collection – September, 1948.

Type	Depth	Texture	pH	Carbonates	Nitrates	Am. thio-cyanate test	Water content	Loss in wt. after ignition
(*a*)	24"	Sandy loam light coloured	8 to 8·5	5	3	±	13·9% on 7-9-48	17·37%
(*b*)	12"	Brown-purple sandy loam	7·5	3	4	±	11% on 7-9-48	27·1%
(*c*)	4"	Brown-purple gravel and sand	7 to 7·5	1	2 to 4	2	3·5% on 15-9-48	3·7%
Play grounds	1 to 2"	Grey gravel and sand ..	7·5 to 8	2 to 3	2 to 3	+	2·5% on 23-10-48	3·5%

(*c*) *Rough Grounds*—The rough grounds form small patches of uneven surface built of pebbles and stones or old deposit of debris and building material lying scattered over the area. Fine sand and sandy loam are caught in between the hard objects and it is not infrequent to find a thick deposit of them. The soil is generally rich in carbonate and nitrate contents.

(*d*) *Eroded Gullies of the slopes*—They do not have any significant amount of soil, but the broken rocks and deposited pebbles on the margins may catch some fine particles of soil just enough to support a few plants. The analytic data for the soil are of doubtful value in giving the character of the substratum, for the small amount of sand collected in between the pebbles every year.

PLANT COMMUNITIES

1. *Slopes*—Among the three characteristic types of slopes the following trees and shrubs have been able to grow only on type 'C', having been initiated under the protection of *Zizyphus rotundifolia*. However, none of them is taller than 15 feet due to frequent lopping.

Acacia arabica, Willd-f; *A. leucophlœa*, Willd-f; *Butea frondosa*, Roxb-d; *Celastrus malcani*, Willd-f; *Holoptelea integrifolia*, Planch-O; *Mimosa rubicaulis*, Willd-f; *Loranthus longiflorus*, Deer-O; *Terminalia glabra*, Bedd-O; *Woodfordia floribunda*, Salisb-O.

A 45 feet long belt-transect of the vegetation was studied along the slope 'C'. A profile of the same is shown in Fig. 3.

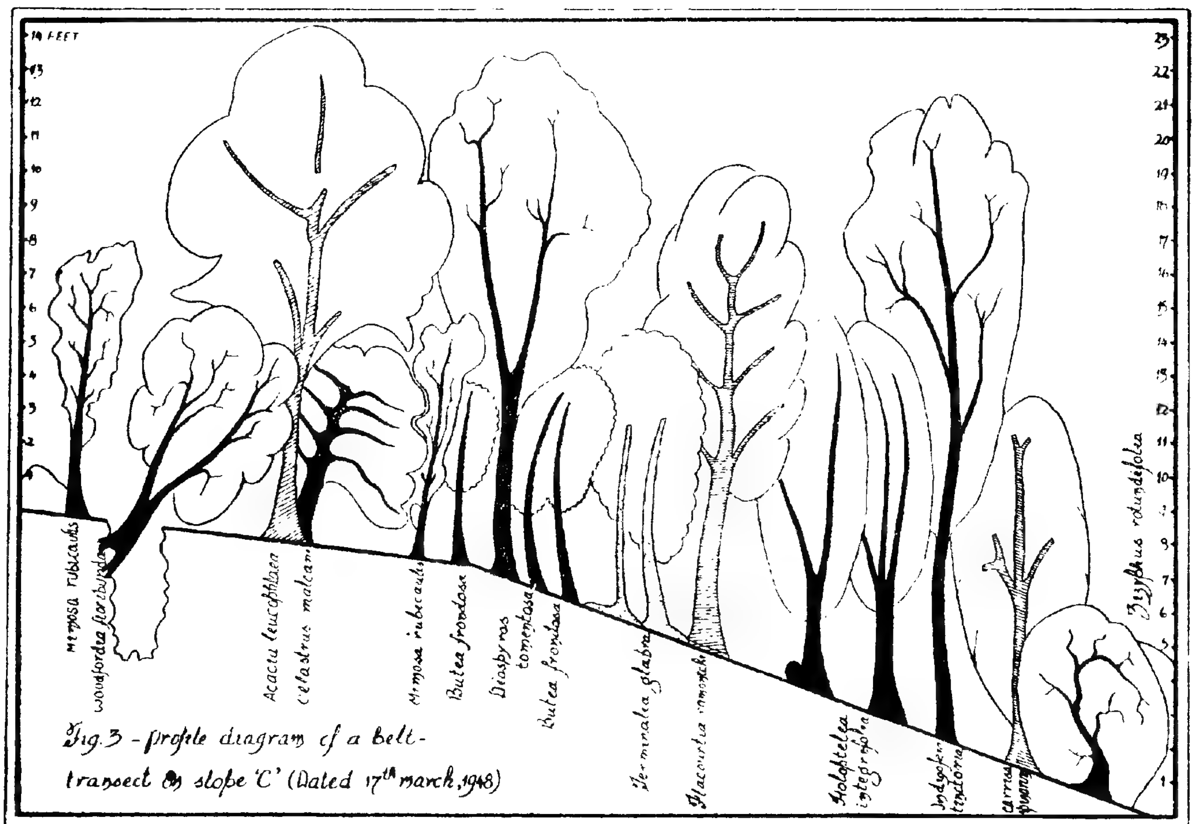

Fig. 3 - profile diagram of a belt-transect on slope 'C' (Dated 17th march, 1948)

GRASSLAND TYPE VEGETATION OF THE SLOPES

Slope 'A'—The average height of the vegetation is 3 to 4 inches. The total cover during the rainy season is 20 to 40%, but it is reduced to about 20% in November and more so in the following dry season. The seasonal variation in the vegetation is given in Tables 4 and 5.

Slope 'B'—This slope, having 90% of the vegetational cover during rainy season is attractive to grazing animals. Most of the vegetation is eaten away from the top. *Heteropogon contortus* with the maximum cover has the best growth in this grassland. *Spermacoce stricta* and *Cassia pumila* have the optimum phase of development in this habitat. *Aristida redacta* and *Tephrosia tenuis* are the exclusive species, being absent or rare on the other types. *Bothriochloa pertusa* shows a great preference for this slope.

During winter season, the biotic factors continue to be intense. However, clumps of *Heteropogon contortus* and *Bothriochloa pertusa* cover about 50% of the total area. *Heylandia latebrosa* grows well here. Only a few species tide over the dry summer. In the Tables 6 and 7 are given the seasonal variation and phytosociological data of the vegetation in rainy season.

TABLE 4

SLOPE 'A'—*List of plants in the three seasons*

(a–abundance ; f–frequent ; Cd–Co-dominant ; O–occasional and r–rare).

The three seasons are denoted by R, W and S.

Species	R	W	S	Species	R	W	S
Aristida redacta	a	..	..	*Justicia diffusa*	r	..	..
Bothriochloa pertusa	f	O	r	*Launæa aspleniifolia*	r	r	..
Cleome simplex	O	..	..	*Polygala chinensis*	O	..	..
Chrysanthellum indicum	r	r	..	*Scilla indica*	r	..	..
Eragrostis viscosa	O	..	..	*Spermacoce stricta*	f	..	..
Echinops echinatus	f	f	f	*Tephrosa tenuis*	f	..	..
Heteropogon contortus	f	f	r	*Tridax procumbens*	f	O	O
Heylandia latebrosa	f	O	O	*Trichodesma indica*	O	O	r
Indigofera linifolia	f	O	r	*Zornia diphylla*	O	..	..
,, *cordifolia*	f	..	..				

TABLE 5

SLOPE 'A'—*Data for the quadrats plotted on the slope 'A'*

(A–abundance ; S–sociability value and C–percentage cover).

Size of the quadrat – 1 sq. metre.

Date : 1st September, 1948　　Average height of vegetation – 3″.

Species	Quad. 1 Total cover 40%			Quad. 2 Total cover 30%			Quad. 3 Total cover 50%			Quad. 4 Total cover 40%		
	A	S	C	A	S	C	A	S	C	A	S	C
Aristida redacta	15	1	6%	60	1	15%	30	1	10%	27	1	5%
Bothriochloa pertusa	3	3	20%	5	3	4%	5	3	20%	7	3	10%
Heteropogon contortus	5	3	10%	3	3	8%	4	3	7%	3	3	5%
Heylandia latebrosa	..	..	..	..	..	..	2	1	3%	2	1	5%
Justicia diffusa	2	..	..	..	..	..	..	..	..	..	..	..
Launæa asplenifolia	..	..	..	1	1	1%	..	..	..	..	..	..
Eragrostis viscosa	..	..	..	13	2	1%	..	..	..	3	..	..
*Polygala chinensis**	1	1	..	..	..	..	..	..	..	3	1	..
Spermacoce stricta	7	3	..	..	..	..	20	3	1%	3	3	..
*Scilla indica**	..	..	..	..	..	..	..	..	..	1	1	..
Indigofera cordifolia	13	4	1%	1	..	..	..	..	..	1	..	..
,, *linifolia*	..	..	..	..	..	..	3	2	2%	5	2	5%
Chrysanthellum indicum	3	1	..	5	1	..	..	..	..	..	..	..
Tridax procumbens	..	..	..	1	1	..	3	3	1%	4	3	2%
Tephrosia tenuis	6	1	1	..	..	..	15	1	5%	17	1	5%
Zornia diphylla	..	..	..	7	1	1%	5	2	1%	..	..	..

* Dried plants.

TABLE 6

SLOPE 'B'—*List of the plants occurring in the three seasons.*

Species	R	W	S	Species	R	W	S
Aristida redacta	f	..	..	*Heylandia latebrosa*	f	f	f
Alysicarpus bupleurifolius	f	O	..	*Indigofera linifolia*	f	f	O
,, *tetragonolobus*	f	O	..	,, *cordifolia*	O	..	..
,, *monilifer*	f	O	..	,, *trifoliata*	O	..	..
Acalypha indica	O	..	..	*Justicia diffusa*	r	..	..
Aristida cyanantha	O	..	..	,, *quinqueangularis*	r	..	..
Biophytum sensitivum	r	r	..	*Kyllinga cyperoides*	O	..	..
Bothriochloa pertusa	d	Cd	f	*Merremia emarginata*	f	..	..
Convolvulus pluricaulis	r	f	O	*Oldenlandia aspera*	r	..	..
,, *arvensis*	r	..	..	*Polygela chinensis*	O	..	..
Corchorus acutangulus	r	r	r	*Paspalidium flavidum*	O	..	..
Cassia pumila	a	..	..	*Spermacoce stricta*	a	..	..
,, *tora*	O	..	..	*Scilla indica*	O	..	..
Cyprus rotundus	r	..	..	*Setaria glauca*	O	..	..
,, *asculantus*	r	..	..	*Schima nervosum*	O	..	..
Chloris virgata	O	O	..	*Sesbania aculeata*	O	..	..
Enicostema littorale	O	..	..	*Tephrosia tenuis*	f	..	..
Euphorbia hirta	O	O	r	*Tridax procumbens*	O	O	O
,, *thymifolia*	O	O	..	*Trichodesma indica*	O	O	O
,, *hypericifolia*	r	..	..	*Urochloa* sp.	r	..	..
Heteropogon contortus	Cd	Cd	f	*Zornia diphylla*	f	..	..
Fimbristyllis diphylla	r	..	..	*Themeda caudata*	O	r	..

TABLE 7

SLOPE 'B'—*Data for the quadrats plotted on the slope Type 'B'*

Size of the quadrat – 0·16 sq. metre.

Date : 26th August, 1948.

Species	Quad. 1 Total cover 100%			Quad. 2 Total cover 90%			Quad. 3 Total cover 90%			Quad. 4 Total cover 90%		
	A	S	C	A	S	C	A	S	C	A	S	C
Aristida redacta	1	1	..	6	1	..	2	1	..	1	1	..
,, *cyanantha*	3	2	..	2	2	..	..	..	..	..	..	..
Alysicarpus bupleurifolius	..	..	..	..	..	..	1	1	5%	..	..	..
Bothriochloa pertusa	2	3	10%	1	..	..	2	3	15%	..	..	..
Cassia pumila	8	1	10%	1	..	..	3	1	5%	3	1	5%
Cyperus esculentus	..	..	..	..	..	..	1	1	..	..	..	..
Cassia tora	1	2	..	1	2	..	..	..	..	..	..	..
Euphorbia hirta	..	..	..	..	..	..	1	..	..	..	..	..
,, *hypericifolia*	3	1	..	1	..	..	..	..	..	..	..	..
Fimbristylis diphylla	..	..	..	1	1	..	..	..	..	3	..	..
Corchorus capsularis	..	..	..	..	..	..	1	1	..	2	1	2%
Heteropogon contortus	13	3	75%	10	3	55%	5	3	50%	10	3	20%
Merremia emarginata	..	..	..	..	..	..	..	..	..	3	4	5%
Paspalidium flavidum	..	..	..	..	..	..	1	1	..	..	..	..
Spermacoce stricta	6	2	..	11	2	2%	7	2	2%	8	2	5%
Setaria glauca	..	..	..	..	..	..	6	1	..	1	1	..
Iseilema anthephoroides	..	..	..	3	3	..	..	..	..	..	..	..
Indigofera cordifolia	..	..	..	4	1	..	..	..	..	..	..	..

Slope 'C'—The average height of the plants is 1 to 2 feet with 99% of the cover during the rainy season. It is possible to make out a field of grasses with their culms attaining a height of even 4 to 6 feet which cover almost all the under-growth. By the end of September the tall grasses are cut by the villagers in the earlier part of the month of October. Heavy grazing follows hereafter. The seasonal aspect of the vegetation is given in the Table 8.

TABLE 8

SLOPE 'C'—*List of the plants in the three seasons*

Species	R	W	S	Species	R	W	S
Acalypha indica	f	..	..	*Enicostema littorale*	f	..	..
Aneilema nudiflora	f	f	..	*Eragrostis tenella*	a	a	f
Andrographis echioidis	f	..	..	,, *elongata*	f	..	..
Alysicarpus rugosus	f	r	..	,, *viscosa*	f	f	..
,, *buplaurifolious*	f	r	..	,, *uniloides*	a	f	r
,, *tetragonolobus*	f	r	..	*Euphorbia geniculata*	f	f	f
,, *monilefer*	f	r	..	,, *hirta*	r	r	r
Apluda mutica	O	..	..	,, *thymifolia*	r	r	..
Aristida cyanantha	f	..	..	*Fimbristylis diphylla*	..	O	..
Biophytum sensitivum	O	O	r	*Heteropogon contortus*	a	a	r
Bothriochloa pertusa	f	O	r	*Heylandia latebrosa*	a	a	f
Commelina nudiflora	O	..	..	*Hoppea dichotoma*	..	O	..
,, *benghalensis*	O	..	..	*Indigofera linifolia*	f	f	r
Chrysenthellum indicum	O	..	..	,, *trifoliata*	O	..	..
Convolvulus arvensis	f	..	..	*Justicia diffusa*	O	..	..
,, *pluricaulis*	O	O	O	,, *quinqueangularis*	O	O	..
Cymbopogon martini	Cd	a	f	*Kyllinga cyperoides*	O	..	..
Crotalaria sericea	f	O	..	*Lagascea mollis*	O	..	..
Cleome simplex	r	..	..	*Malvastrum coromandalina*	O	..	..
Corchorus acutangulus	O	O	r	*Merremia emarginata*	f	..	..
,, *trilocularis*	O	O	..	*Oldenlandia aspera*	..	O	..
Dichanthium annulatum	O	O	O	*Polygonum plebejum*	..	O	..
Digitaria sanguinalis	O	O	..	*Sesbania aculeata*	O	..	..
Phyllanthus naviruli	O	..	..	*Themeda caudata*	O	..	..
Polygela chinesis	r	..	..	*Themeda caudata*	d	Cd	O
Setaria glauca	O	..	..	*Urochloa reptans*	r	..	..
Spermacoce stricta	a	..	..	*Vicia sativa*	r	..	..
Sehima nervosum	O	O	r	*Zornia diphylla*	O	..	..
Sida ordifolia	O	..	..	*Tridax procumbens*	f	O	r
,, *rhombifolia*	f	O	O	*Trichodesma indica*	f	O	r
,, *verenicæfolia*	O	O	r	*Paspalidium flavidum*	O	..	..

2. *Level Grounds*—Soon after the early monsoon showers *Scilla indica* comes out from its previous year's bulb. It is most abundant and prominent species of the grassland at this time. *Scilla indica* grows vigorously on the deep soil type of level grounds at well drained places.

(*a*) The characteristic species of the deep soil type locality 'a' in the rainy season are :—

Chloris virgata (d), *Bothriochloa pertusa* (Cd), *Iseilem-a anthephoroides* (a), *Heteropogon contortus* (f), *Polygala chinensis* (f), *Kyllinga cyperoides* (f), *Sehima nervosum* (f), *Alysicarpus* sp. (f), *Eragrostis elongata* (O), *E. viscosa* (f), *Zornia diphylla* (O), *Bœrhaavia diffusa* (O), *Indigofera linifolia* (f) and *Heylandia latebrosa* (f). The last named has optimum phase of growth. *Indigofera linifolia* prefers the habitat, and may send the roots down up to even 4 feet.

(*b*) In the intermediate type 'b' of the level grounds *Iseilema anthephoroides* and *Sehima nervosum* are found occasionally. The other species of the place are the same as recorded for the deep soil type locality 'a'. They are followed early in the dry cold season by *Andropogon pumilis* which turns red due to the development of anthocynin pigment.

(*c*) The thin soil type locality 'c' has only 40 to 50% of plant cover. The soil being only 2 inches thick the species are generally depuaperated. The dominant species of the type during rainy season are :—*Zornia diphylla* and *Indigofera cordifolia*. *Eragrostis viscosa* has a high density. *Eleusine aegyptiaca* and *Indigofera linifolia* have high frequency but low density. The total number of species found per quadrat (of area 0·16 sq. metre) was as low as 3 to 5 and the total number of plants were 20 to 25. The variations in the vegetation in different seasons and the quadrat's data for given below :

TABLE 9

LEVEL GROUNDS—*Data for the quadrats plotted in the different habitats of level grounds*

Date : 26th and 27th August, 1948. Quadrat : 0·16 sq. metre.

Species	Locality 'a' cover 95%				Locality 'b' cover 95%				Locality 'c' cover 75%				Play ground cover 60%			
	A	S	F	C	A	S	F	C	A	S	F	C	A	S	F	C
Andropogon pumilus ..	45	2	5	20%	..	..	..	..	2	1	1	..	..	..	..	..
Alysicarpus molinifer ..	6	1	3	5%	1	1	1	·5%	..	..	..	..	..	..	..	..
,, *bupleurifolious*	12	3	3	10%	4	1	4	·2%	1	1	3	·1%	..	..	..	..
,, *tetragonolobus*	1	1	1	..	..	..	..	..	2	1	2	·2%	1	1	1	·2%
Aristida redacta ..	..	..	..	..	..	..	..	..	2	1	1	..	..	..	..	..
Bœrhaavia diffusa ..	1	1	2	2%	..	..	..	..	..	..	..	..	1	1	2	1%
Bothriochloa pertusa ..	2	2	1	1%	2	2	5	20%	5	5	2	3%	..	..	..	..
Cassia pumila ..	3	1	4	3%	..	..	..	..	4	1	1	8%	1	1	1	·5%
Chloris virgata ..	5	1	3	3%	..	..	..	..	..	..	..	..	..	..	..	..
Cynodon dactylon ..	..	..	..	..	4	4	2	2	..	..	..	..	..	..	..	..
Cyprus asculantus ..	2	1	2	..	..	..	..	..	..	..	..	..	..	..	..	..
Eleusine aegyptica ..	4	1	2	2%	..	..	..	..	3	1	3	1%	28	2	5	22%
Eragrostis viscosa ..	14	2	4	7%	..	..	..	..	25	3	4	9%	25	3	5	10%
Euphorbia Sp. ..	2	1	3	2%	..	..	..	..	2	1	1	·6%	11	1	5	4%
Heteropogon contortus ..	3	3	1	12%	..	..	..	..	..	..	..	..	..	..	..	..
Heylandia latebrosa ..	1	1	1	20%	1	1	1	5%	..	..	..	..	..	..	..	..
Indigofera linifolia ..	1	1	2	1%	6	2	2	25%	3	2	5	2%	..	..	..	..
,, *cordifolia* ..	..	..	..	..	..	..	..	..	63	4	5	20%	..	..	..	..
Merremia emarginata ..	30	5	5	10%	4	2	2	5%	..	..	..	..	..	..	..	..
Polygela chinensis ..	1	2	2	·5%	..	..	..	..	1	1	1	..	..	..	..	..
Paspalidium flavidum ..	3	1	3	·5%	..	..	..	..	..	..	..	..	3	1	4	·2%
Sehima nervosum ..	..	..	..	..	3	1	4	10%	..	..	..	..	..	..	..	..
Setaria glauca ..	1	1	4	..	1	1	2	..	..	..	..	..	5	1	5	2%
Spermacoce stricta ..	1	1	2	..	1	1	1	..	..	..	..	..	1	1	2	..
Zornia diphylla ..	10	2	5	2%	..	..	..	..	57	5	5	30%	3	1	5	1%

Foot-path—The vegetation of the foot-path is greatly modified by trampling. During the rainy season the following species were found on the foot-path situated on level grounds 'b'. *Cynodon dactylon*, *Indigofera linifolia*, *Setaria glauca*, *Eleusine aegyptiaca* and *E. indica*. *Urochloa reptans* was found in depauperate condition. Most of these species dry up in winters. *Euphorbia* Sp. (almost dry), *Indigofera linifolia*, and *Cynodon dactylon* alone persisted for sometime. Due to very low water content in this habitat all the species completely disappear during summers, when the tract merges into the surrounding grassland.

Play Grounds—During the rainy season, fields being unused supported the vegetation of an average height of 2-inch with 60% of the ground covered by it. All the species grow in depauperate form. *Eleusine œgyptica* and *Setaria glauca* are the first plants to appear in the rainy season. They are followed by the growth of *Zornia diphylla*, *Indigofera cordifolia*, *Eragrostis viscosa* and *Euphorbia* Sp. Out of these species *Eleusine œgyptiaca* and *Eragrostis viscosa* are the dominant ones in the month of September. In the month of February, 1948 (the Hockey field was left unused during that month) only two species of *Euphorbia*, viz., *Euphorbia thymifolia* and *E. microphylla* were growing in the hockey field. The plants were especially growing inside the 'D' of the field. They formed a cover of 70% of the grounds. It was interesting to note that the two species, named above, were growing separately in colonies. By the month of April the third species which shoots up from the remains of the underground stem is *Bœrhaavia diffusa*.

3. *Rough Grounds*—The surface being uneven, the habitat is not so frequently visited by the grazing animals. Therefore, a large number of herbs and shrubs are found in this habitat in all seasons. And it is not unlikely that some tall shrubs and trees characteristic of the area may grow here in a few years, if not cleared by man. The species are detailed in Table 10.

4. *Eroded Gullies*—In between the boulders, on the thin layers of eroded soil in these gullies, the following commonest species occur during the rainy season. *Themeda caudata* and *Apluda aristata*. The other characteristic species are :—*Saccharum spontaneum*, *Andropogon pumilus*, *Andrographis echiodes*, and *Heteropogon contortus*. In the dry season when the water content of the sandy substratum falls low, only the following two species are visible—

Tridax procumbens and *Heylandia latebrosa*. *Woodfordia floribunda* and *Celastrus malcani* may also be found occasionally.

TABLE 10

ROUGH GROUNDS—*List of the plants occurring in the three seasons on rough grounds*

Species	R	W	S	Species	R	W	S
Acalypha indica	O	..	..	*Amaranthus spinosus*	f	O	O
Achyranthes aspera	O	..	..	*Bothriochloa pertusa*	a	f	f
Alysicarpus bupleurifolius	f	O	..	*Biophytum sensitivum*	O	O	r
,, *rugossus*	O	r	r	*Cassia tora*	d	..	..
,, *tetragonolobus*	f	O	..	*Chloris virgata*	f	O	..
Anagallis arvensis	..	f	..	*Crotalaria sericea*	..	O	..
Andropogon pumilus	O	..	..	*Canscora diffusa*	..	f	..
Aneilema nudiflora	..	O	..	*Digitaria sanguinalis*	f	O	..
Apluda aristata	O	..	..	*Dichanthium annulatum*	a	f	f

(*contd.*)

TABLE 10—(*concld.*)

ROUGH GROUNDS—*List of the plants occurring in the three seasons on rough grounds.*

Species	R	W	S	Species	R	W	S
Enicostema littorale	f	..	..	*Justicia quinqueangularis*	O	O	r
Eclipta erecta	O	O	..	*Launea asplanifolia*	O	f	..
Exacum pedunculatum	..	f	..	*Lagascea mollis*	f	..	..
Eragrostis viscosa	f	f	r	*Malvastrum coromandalianum*	O	..	..
,, *elongata*	O	..	..				
Celastrus malcanci	O	O	O	*Merremia emarginata*	f	O	..
Corchorus fascicularis	O	O	O	*Melilotus indica*	r	r	..
,, *trilocularis*	r	..	..	*Nepeta hindustana*	..	O	..
Convolvulus arvensis	f	..	..	*Polygonum plebajum*	..	O	..
,, *pluricaulis*	r	O	O	*Phyllanthus naviruli*	O	r	..
Cyanotis cristata	O	..	..	*Polygala chinensis*	f	..	..
Commelina nudiflora	f	..	..	*Saccharum munja*	r	..	..
,, *benghalensis*	f	..	..	,, *spontaneum*	O	O	O
Argemone mexicana	f	f	f	*Setaria glauca*	O	..	..
Aristata redacta	O	..	..	*Solanum nigrum*	O	O	O
Euphorbia hirta	O	O	O	,, *xanthocarpum*	O	O	O
,, *pulcharyma*	..	O	..	*Sesbania aculeata*	O	..	..
,, *thymifolia*	O	O	O	*Cleome simplex*	f	..	..
Guizotia abyssynica	..	f	O	,, *viscosa*	O	..	..
Heteropogon contortus	f	f	O	*Themeda caudata*	f	O	r
Heylandia latebrosa	f	f	O	*Tridax procumbens*	f	f	f
Hoppea dichotoma	..	O	..	*Trichodesma indica*	f	f	O
Indigofera linifolia	O	O	O	*Zornia diphylla*	f	..	..
Justicia diffusa	O	..	..	*Zizyphus rotundifolia*	O	O	O

PLANT RESPONSES TO ENVIRONMENTAL CONDITIONS

It was observed that a large number of plants showed variations in morphology, habit and physiology due to changes in the season, the soil and the nature of biotic factors. Bonnier (1894), Masclaf (1892), and Gupta (1937), etc., have clearly shown that edaphic factors play as great a part as any other environmental factors. Hence the following six perennial species were selected for a close study in relation to the soil and seasonal conditions.

PROSTRATE HERBS—*Indigofera linifolia* Wight, and *Heylandia latebrosa* Dc.

GRASSES—*Themeda caudata* Dur. et Jack and *Dichanthium annulatum* Stapf.

TALL HERBS—*Tridax procumbens* Linn. and *Trichodesma indica* Br.

1. *Trichodesma indica* and *Dichanthium annulatum*—The habits of the species are remarkably altered by the periodic climate. This seems mainly in response to the water content of the soil. Plants of both the species were observed in the following localities of the plateau in November, 1948 : Slope type 'A' ; Thick soil type level grounds 'a', Rough grounds.

Morphology of roots—There seems some correlation between the length of the main rooting system of the species and depth, texture and water content of the soil. Roots tend to be longer, thinner and less in cover in light coarse calcareous sand on Slope 'A', and on thin soil type level ground 'c'. In the following table is given the rooting depts of the two species in relation to water and carbonate contents of the soil.

TABLE 11

Rooting depth of *Trichodesma indica* and *Dichathium annulatum* in relation to water and carbonate content of the soil at different localities.

Locality	Depth of soil	Texture of soil	Carbo-nate	Water content	Rooting depth	
					T. indica	*D. annulatum*
				%	"	"
Slope 'A' ..	1·4"	Clay chalky and coarse sand	8	2·5	16·6	14·3
Level grounds type 'a'	up to 2 ft.	Fine sandy loam	5	7·1	12·9	12·75
Rough grounds ..	1 to 2 ft.	Fine sandy loam	4	14	19·25	8·5

Area of leaves—The area of the leaves, too, seems to be closely related to the water content of the soil ; probably higher the available water the larger the leaves in the same season. Comparing the leaf areas from different localities it is clear that lime decreases the water holding capacity of the soil and thus the leaves are smaller there. The average leaf areas are as under :

Locality	Area of the leaf of	
	T. indica	*D. annulatum*
	Sq. inch	Sq. inch
Slope 'A'	0·34	0·45
Level grounds type 'a' :	0·86	0·75
Rough grounds ..	3·75	1·2

(Fig. 4. Shows the relation of the leaf area of *Trichodesma indica* with water content of the soil).

2. *Tridax procumbens*—It seems to be a calcicole. But it was not found to thrive well on slope 'A', probably due mainly to the thinness of the soil and deficiency of water. It is a characteristic species growing in abundance along building, where it finds sufficient lime and water. A non-calcareous soil having high water content does not seem to suit it. The length of the roots and area of the leaves were greatest in case of the plants growing along buildings. In Table 12 are given the average area of leaf and mean rooting depth of *Tridax procumbens* as found at different places. (Fig. 4 shows the area of the leaf of *Tridax procumbens* in relations to carbonate content of the soil).

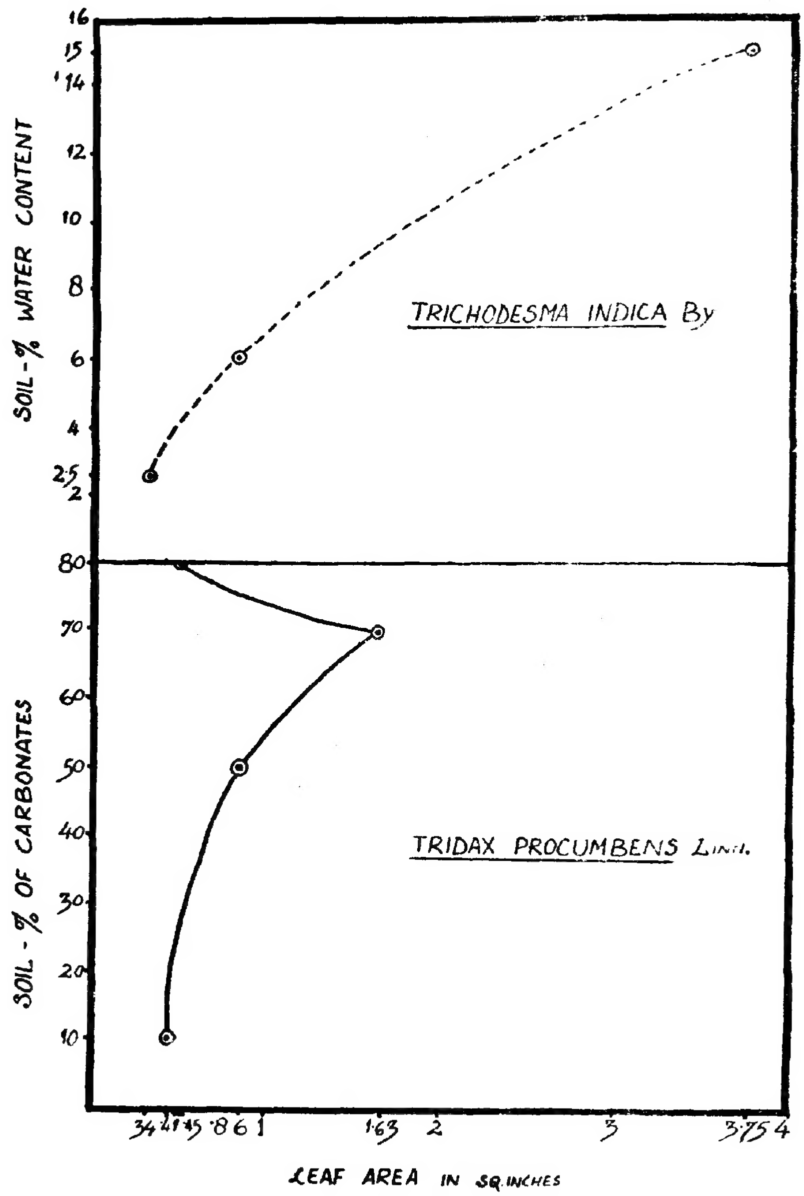

Fig. 4.

3. *Indigofera linifolia* and *Heylandia latebrosa* —The growth of these species, having optimum phase in the thick soil type locality 'a' of the level grounds, seems to be correlated with the depth of the soil and its water content. The species are remarkable in having long roots penetrating up to 5 feet deep.

Morphology of the roots—The length of the roots in the soil of type 'c' of the level grounds which has gravel and sand was more or less same as found on the slope 'A'. But

records of th length of the main root in the former case is greater. The roots of the plants growing in thick soil type 'a' locality of the level grounds were largest up to 5 feet.

Area of the leaf—Shape and area of the leaves vary much from locality to locality. Leaves from the plants growing on thick soil type habitat 'a' of the level grounds have largest area. Leavos of *Indigofera linifolia* are lanceolate in shape and that of *Heylandia latebrosa* are oval. But in other habitats having thin gravel and sandy soil, the plants had minute oval type of leaves in both the cases. The following table gives the rooting depth and average area of the leaves of *Indigofera linifolia* and *Heylandia latebrosa* as found at different habitats.

TABLE 12

Mean area of a leaf and average rooting depth of *Indigofera linifolia, Heylandia latebrosa*, and *Tridax procumbens* as found at different habitats.

Locality	*I. linifolia*		*H. latebrosa*		*T. procumbens*	
	Area of leaf	Rooting depth	Area of leaf	Rooting depth	Area of leaf	Rooting depth
	Sq. in.	inch	Sq. in.	inch	Sq. in.	inch
Thick soil type 'a'	0·085	38·5	0·15	28·5	0·85	10·3
Along buildings	0·075	28·9	0·75	44·7	1·63	7·3
Slope 'A'	0·032	15·2	0·035	34·2	0·45	9
Thin soil type 'c'	0·02	15	0·02	38·6	0·41	8·0

4. *Themeda caudata*—The species grow exclusively on the slope type 'C', being absent or rare at other habitats. The significant character of this slope is a deep moist soil. The species was found to vary in morphological characters during the three seasons. From the Table 13 given below, it is clear that the optimum phase of growth is during the rainy season when the plants are 5 to 6 feet tall. During winters the height is reduced to 1½ feet; and in summer, the few plants growing in the garden with a better supply of water, did not attain a height of more than 6 to 8 inches.

TABLE 13

Rooting depth and mean area of the leaf of *Themeda caudata* growing in different habitats during the three seasons.

Locality	Climatic seasons	Rooting depth	Mean area of a leaf
		inch	Sq. in.
Slope 'C' ..	Rainy	6·3	0·66
	Winter	9·0	0·32
	Summer	15·9	0·27
Rough grounds ..	Rainy	6·5	0·68
	Winter	8·5	0·3
	Summer	16·6	0·25

The above studies further need detailed analytic and cultural observations.

SUMMARY

1. The Makronia plateau is situated at an altitude of 1,890 feet to the east of Sagar, Madhya Pradesh.

2. The plateau is built of the Deccan Trap formed towards the close of the Cretaceous age. The rocks are augite-basalt and black to lighter shades in colour. They are rich in minerals. Under the local climate, sub-aerial weathering leads to the production of a highly argilaceous dark loam. The intertrappean beds consist of impure limestones and clay which weather into calcareous soil mixing up with the products of basalt by transportation or by leaching.

3. The climate if markedly periodic.

4. The habitats are classified according to the topography as : Slopes of the plateau, plateau terraces (level grounds), rough grounds, and strongly eroded gullies. The slopes and the plateau terraces (level grounds) are further divided according to the texture and depth of soil.

5. The plant communities found on each type of habitat is described.

6. Variability with regard to rooting depth, leaf area and size, and height of six perennial species is shown in relation to soil and climatic season.

Tridax procumbens is probably a calcicole growing gregariously along buildings. *Themeda caudata* is a strongly seasonal perennial having optimum phase of growth in the rainy season. *Trichodesma indica*, *Dichanthium annulatum*, *Indigofera linifolia* and *Heylandia latebrosa* seem to be governed by the water content of the soil which in turn depends upon its texture, depth and lime content. The higher the water content better the growth.

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